DEVELOPMENT AND QUALITY EVALUATION OF SELECTED HONEY BASED FOOD PRODUCTS

ABSTRACT

THESIS

SUBMITTED FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy

IN

HOME SCIENCE

BY

SANGEETA VERMA

Under the Supervision of

Dr. Anisa M. Durrani

Reader, Deptt of Home Science

Co-Supervisor:-

Prof. P.K. Srivastava

Ex-Chairman, Deptt of Post Harvest Engg. & Tech

DEPARTMENT OF HOME SCIENCE
FACULTY OF AGRICULTURAL SCIENCES
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

2009

Abstract

The word 'Honey' is derived from the Arabic word 'han'. This became 'honing' in German and 'hunging' in old English. Honey is also known as 'miel' in French and Spanish, 'honig' in Dutch, 'meli' in Greek, 'mel' in Latin, 'mej' in Hungarian, 'meile' in Italian and 'madhu' in Hindi / Sanskrit. It is used in English as a term of 'endearment'. Honey means the food derived entirely from the work of bees operating upon the nectar of flowers and other sweet exudation of plants. It shall not contain more than (a) 25% of moisture (b) 0.5% ash and (c) 5% of sucrose except in case of Carvia Callosa and honey dew where the maximum sucrose content shall be 10%. The minimum reducing sugar content (expressed as invert sugar) shall be 65% except in case of Carvia Callosa and honey dew where it shall be 60% Fructose / Glucose ratio shall not be less than 0.95 and Fiehe's test should, ordinarily be negative (Sharma, 2000).

Honey is enjoyable on account of its distinct flavour and taste. It has high viscosity, sweetness and range of colours. It is valued as a food as well as for its therapeutic attributes (Shamala and Jyothi, 1999).

Honey and its source 'honey bees' have been associated with human from the time immemorial. From the Vedic references it is well known that Indians knew about the food and medicinal value of honey because of which it was rated next to 'Amrit', the Ambrosia only. Chinese in ancient times used honey as superior medicine. Greeks and Egyptians used honey to embalm the dead bodies. It was also used as food for dead and it is reported that in tomb of a queen of Egypt, who was buried over 3000 years ago, a jar of honey was found intact in its chemical composition and its original aroma (Sharma, 2000).

Nutritionally honey is a high energy carbohydrate food considered to be best source of heat and energy giving over 3200 Kcal energy/kg. It provides wholesome nourishment as compared to other foods. The energy value of one kg of honey is approximately estimated to be equal to 19 eggs, 3kg milk, 6.5kg plums, 3.5kg green peas, 5.5kg apples or 7kg carrots (Gopalan et.al, 2004). Being an energy rich food, it becomes a perfect food when consumed with milk.

Medicinally honey is non- irritant, promotes rapid growth of healthy tissues and is useful in pruitus value, bed sores, skin and intestinal disorders. It is very commonly used internally in treatments of cough, cold, hey fever, gastro-intestinal disorders etc. It quickly replenishes the energy lost in various physical activities. Athletes and sportsman, mountaineers, deep-sea drivers, patients in hospitals and workers in factories are some of the special segments of society who requires the honey the most.

Honey is a versatile product that suits all occasions viz. religious ceremonies, spiritual functions, festivals and at the time of birth, marriages and even death. Infact, honey is considered as the food of foods, the drink of drinks, and drug of drugs. Being a versatile product, it is used for creating appetite, strengthening the stomach, eliminating phlegm, as a meat preservative, hair conditioner, eye salve and mouth wash.

Informations on above aspects related to use of honey all over world are lacking in published literature. Most of the research studies in relation to processing and utilization of honey pertain to HMF (hydroxy methyl furfural) formation during storage, effect of heating on HMF and browning, influence of heating (direct heat treatment), storage temperature and period, physico-chemical and sensory qualities of Indian honey, glucose content in honey, total soluble solids (TSS), acidity, pH and standard plate count as affected by different treatments and storage conditions etc. The product development and product characteristics aspects are missing in literature.

Keeping in view the above considerations the present research work was planned to develop and evaluate some promising honey based food products in which honey could be substituted in place of white sugar and which have longer shelf life. The specific objectives of the study were:

- To develop and standardize the procedures for manufacturing of selected honey based nutritional food products like honey aonla preserve, honey carrot candy, honey jam, honey chocolate/toffee and honey beverages.
- To study and evaluate the relevant physico-chemical, textural, nutritional, sensory and microbial characteristics of above developed food products.
- To evaluate the shelf life of above products in various packaging materials.

- Statistical and economic analysis for commercialization of developed products.

It is expected that the findings of this study will be utilized by various sections of society for increasing the consumption of medicinal honey as healthy food with additional advantage of ease in consumption, value-addition besides producing therapeutically advantageous designer foods with variety and taste. Such utilization will also encourage establishment of cottage industries and generate newer opportunities of income/employment generation in rural areas and enhance the economic of beekeeping in India.

Federal Food and Durg Administration USA, has given following definition of honey: 'Honey is the nectar and saccharine exudations of the plants gathered, modified, and stored in the comb by honeybees (Apis *mellifera and A. dorsata*), is levorotatory, and contains not more than 25 per cent of water, not more than 0.25 per cent of ash, and not more than 8 per cent of sucrose' (Harry, 2001).

Thus, honey is produced by honeybees. They suck up nectar from flowers or other sweet saps found in living plants, store the nectar in their honey sac, and enrich it with some of their own substances to induce changes. When the bees return to the hive, they deposit the nectar in honeycombs for storage and ripening.

Honey production starts immediately after the flower pollen, nectar and honeydew are collected and deposited in the bee's pouch (honey sac). The mixture of raw materials is then given to worker bees in the hive to deposit it in the six-sided individual cells of the honeycomb. The changing of nectar into honey proceeds in the cell in the following stages: water evaporates from the nectar, which then thickens; the content of invert sugar increases through sucrose hydrolysis by acids and enzymes derived form bees, while an additional isomerization of glucose to fructose occurs in the honey sac; absorption of proteins from plant and bees, and acid from bee's body; assimilation of forage minerals, vitamins and aroma substances; and absorption of enzymes from the bee's salivary glands and honey sacs. When the water content of the honey drops to 16-19%, the cells are closed with a wax lid and ripening continues, as reflected by a continued hydrolysis of sucrose by the enzyme invertase and by the synthesis of new sugars.

On the basis of the source of sweet liquid and also the plant species in case of floral and extra floral nectar, the honey can be classified as floral honey or dew honey. Though mono floro honeys are not common viz, honey can be categorized on the basis of floral source such as Litchi honey, Berseem honey, Eucalyptus honey, Brassica honey etc. It is also very common to name the honeys on the basis of colour.

The honey can also be classified as apiary honey and forest honey. The honey produced by hive bees, *Apis cenara indica* and *Apis mellifera* in apiaries; collected by modern extraction methods is called apiary honey. These are transparent and free from foreign materials. Forest honey includes honey produced by rock bee, *Apis dorsata* or wild nest of *A. cenara indica* in forest and collected by crude methods of squeezing the comb. Such honey is turbid due to presence of lot of pollen, wax, brood, and other parts of bees and plant materials.

According to recovery techniques, following kinds of honey are differentiated:

(a) Comb Honey (honey with waxy cells), i.e. honey present in freshly built, closed combs devoid of brood combs (young virgin combs). Such honey is produced in high amounts, and is widely available. Darker colored honey is obtained from covered virgin combs not more than one year old and from combs, which include those used as brood combs.

(b) Extracted Honey is obtained with a honey extractor, i.e. by centrifugation at somewhat elevated temperatures of brood-free comb cells. This recovery technique provides the bulk of the honey found in the market. Gentle warming up to 40^0 C facilitates the release of honey from the combs.

(c) Pressed honey is collected by compressing the brood-free honeycombs in a hydraulic press at room temperature.

(d) Strained honey is collected from brood-free, pulped or unpulped honeycombs by gentle heating followed by pressing.

(e) Beetle honey is recovered by pulping honeycombs, which include brood combs. This type of honey is used only for feeding bees.

Depending upon the sucrose content honey can also be classified as natural honey and artificial honey. Natural honey is produced by honeybees while artificial honey is mostly inverted sucrose from beet or cane sugar and is produced with or without starch

sugar or starch syrup. It is adjusted in appearance, odour and flavour to imitate true honey. Depending on the production method, such honeys contain nonsugar constituents, minerals, and sucrose and hydroxymethyl furfural. Artificial honey contains invert sugar (≥50%), sucrose (≤38.5%), water (≤22%), ash (≤0.5%) and, when necessary, saccharified starch products (≤38.5%). The aroma carrier is primarily phenylacetic acid ethyl ester and, occasionally, diacetyl, etc. Hydroxymethyl furfural content is 0.08-0.14%. The product is often coloured with certified food colours. Artificial honey is used as a sweet spread for bread and for making Printen (honey cookies covered with almonds), gingerbread and other baked products.

Certain honey based fruits and vegetables products like honey aonla murabba, honey carrot candy, honey mixed fruit jam, honey aonla squash and honey toffee were developed by replacing white sugar with honey. Experimental studies were carried out to examine the effects of different packaging materials and storage temperature on various physico-chemical, textural, microbiological and organoleptic characteristic of these honey based food products. Shelf life studies of different developed products were also carried out.

Honey and large sized aonla (Varity: Banarsi) were procured from the K.V.K. Aligarh and orchards of the Agricultural Faculty of A.M.U., Aligarh respectively. Carrot, papaya and guava were procured from the local fruits and vegetable's shops. Compositional constituents of honey and fruits and vegetables used in this study were determined before preparation of the honey based food products.

A number of equipments and Apparatus were required to conduct the present study. These included Digital pH meter for pH measurement (Thermo Orion USA), Soxhalate apparatus for fat estimation (Borosil Glass), Laminar flow for microbial studies (Yarco, India), B.O.D. cum humidity chamber (Yorco, India), Autoclave (Pooja Scientific instrument, New Delhi), High Speed Tissue Homogeniser (Yorco, India), Hot Air Oven for moisture content (Tanco, India), Electronic Balance (Anamed, India), Spectrophotometer for determination of browning index (Digital Spectrophotometer Model 310E, India), Atmospheric Packaging Machine (Quick Seal, Sevana, India), and Texture Analyzer for textural properties (TAHD Stable Micro system, England) etc in addition to glassware's and electronic balances.

For the preparation of Honey Aonla Murabba: One kg Honey was used for the preparation of murabba. The recipe included following:

Aonla fruit	——	1.00 kg
Honey	——	1.00 kg
Water	——	150 ml
Citric acid	——	2-3 g

Fruits were washed with cold water and after the damaged ones were discarded, they were properly cleaned and pricked with stainless steel fork/ knife and immersed in two percent NaCl solution at room temperature. Concentration of the solution was increased by two percent/day and the operation was continued for four days. Fruits were taken out form the Nacl solution after four days and washed thoroughly and dipped in fresh water for 1-2 days. The cleaned fruits were blanched in 1-2% potash alum solution for 4-5 minutes or until separation of segments was observed when the fruits were hand-pressed. After the blanching fruits were washed thoroughly to remove the traces of alum. The blanched fruits were transferred in honey syrup of 55-60°Brix and kept in it for one night. Next day fruits were taken out from the syrup and the syrup was boiled .The syrup was cooled and added again with the fruits .The product was kept again for 24 hours. On third day, the process was repeated with addition of the fruits in hot syrup and the product was kept again for two days at ambient temperature. After two days, the fruits and syrup were boiled together till syrup obtained 68-70°Brix corresponding to temperature of 105-106°C. The product was allowed to cool and packed in clean and sterilized dry glass and PET jars, which were stored in cool and dry place.

For the preparation of Honey Carrot Candy: 750g of honey was used for the preparation of one kg candy. The recipe included following:

Carrot	——	1.00 kg
Honey	——	750 g

After washing, peeling and removing inedible portion, the carrots were pricked with stainless steel fork and cut into pieces of 1.25-1.5 cm. lengthwise. The pieces were blanched in boiling water for 5 minutes and blanched pieces were placed on a dry cloth and excess water was allowed to drain off. The pricked and blanched pieces were soaked in honey syrup at room temperature overnight. Next day, the carrots were taken out from

the syrup and syrup was boiled. The syrup was cooled and added again with carrots. The product was kept again for 24 hrs. On third day, the process was repeated with addition of carrots in hot syrup and product was kept again for 24 hrs. Next day, the carrots and syrup were cooked together till the candies obtained 68°Brix. The pieces were dried at room temperature till non-sticky. The prepared candies were packed and stored.

For the preparation of Honey aonla Squash: 600 ml Aonla fruit juice and 400 ml of honey were used in the preparation of one litre honey aonla squash. The recipe included following:

Aonla fruit juice — 600 ml
Honey — 400 ml
Citric acid — 2 – 3 g
Kms — 350 ppm

Fruits were washed with cold water and after the damaged ones discarded , they were properly cleaned and heated in boiling water for 15 mins. The seeds were removed and water added in 1:1 ratio. The separated segments were passed through a pulping machine to get pulp. The juice was strained and mixed with honey, citric acid and kms. Now bottling, capping and labeling was done and stored in room temperature or in refrigerator.

For the preparation of Honey Mixed Fruit Jam: 750g of honey was used for the preparation of one kg mixed fruit jam. The recipe included following:

Papaya — 500 g
Guava — 500 g
Honey — 750 g
Citric acid — 10.0 g

Fully matured, sound and uniform sized fruits were cleaned, washed with tap water and manually peeled and cut in to small pieces. The seeds were removed and pieces were passed through mixer to get homogenized pulp. The pulp was concentrated and other ingredients (honey, citric acid) were added. The cooking of pulp was continued till the jam obtained 68.5°Brix. Now bottling and cooling of jam in glass bottles was done and stored in room temperature or in refrigerator.

For the preparation of Honey toffee: Honey (200g) was taken into a boiling pan and heated up to 1 min. then milk powder was added with continuos thorough mixing and heating continued at low flame for 12-15 min. now 24g hydrogenated fat was added and heating was continued for 4-5 min. at low flame. After heating was stopped, the mass thus obtained was spread over stainless steel tray and allowed to cool down for 5 min. The semi solid mass was now fed to the moulding machine for moulding the toffee into the desired shape and size. The toffee thus obtained mass was allowed to dry for 1.5h. After drying, toffee are individually wrapped in metalized polypropylene sheets manually. These wrapped toffees were then packed in LDPE bag of 500g capacities.

After the preparation of sample, Physico-chemical, microbiological, textural and organoleptic characteristic was determined.

Microbial analysis was done aseptically to determine the total plate count of the samples on Nutrient Agar (NA) for bacterial count, Potato dextrose Agar (PDA) for yeast and mold count and Mac Conkey Agar for coliform count.

Sensory attributes such as colour, aroma, texture, taste, juiciness and mouth feel of the honey based products were evaluated as recommended by Ranganna (1994) by Hedonic rating test. A semi-trained panel consisting of 14 judges was selected to evaluate the sample through properly planned experiments. The panelists were selected from the staff and students of Department of Post Harvest Engg. and Technology, Faculty of Agricultural Sciences, AMU, Aligarh.

Texture profile analysis (TPA Test) was done according to

Fracturability

Fracturability is defined as the force required to rupture the material and is measured as the force at the first significant break in the first positive bite area.

Cohesiveness

Cohesiveness is the property of the material, which determines the extent of deformation. The material withstand file before it ruptures. It is evaluated as the ratio of the positive force area during the second compression cycle to the positive force area during the first compression cycle.

Hardness

It is defined as the force necessary to attain a given deformation and is evaluated as the peak force during the first compression cycle. The hardness of any biological material is important parameter for its textural evaluation and quality control in terms of maturity, ripeness and storability.

Fracturability= Not all products fracture; but when they do fracture the Fracturability point occurs where the plot has its first significant peak (where the force falls off) during the probe's first compression of the product.

Cohesiveness $= PA_2/PA_1$ (PA_1 and PA_2 are the areas of first and second bite)

Hardness $= h_1$ (Peak force) during first compression

Springiness =Height to which the food recovers between end of the first byte and start of the second byte

Guminess = hardness x Cohesiveness

$= h_1 \times PA_2/PA_1$ (Where h_1 is the hardness)

Stickiness = -Ve peak force during first compression

Analysis of economics of manufacturing of honey based food product, taking several assumptions into consideration. Following economic indicators were worked out.

$$\text{(1) Pay back period} = \frac{\text{Total capital investment + Working capital}}{\text{Net annual profit + Depreciation}}$$

$$\text{(2) Return on investment} = \frac{\text{Net annual profit}}{\text{Total capital investment + Working capital}} \times 100$$

$$\text{(3) Benefit cost ratio} = \text{Annual benefit / Total annual cost}$$

(4) Break even point

For x to be brake even point in days

Fixed cost per year + variable cost per day X x = Revenue per day X x

It is well known that white sugar contains very high amount of sucrose and is an extremely poor food. The excessive consumption of sucrose quite often leads to variety

of health problems, which can be avoided by replacing white sugar with natural sweeteners like honey. Honey is a complex mixture of carbohydrates, several enzymes, amino acids, organic acids, minerals, aroma substances, pigments etc. In comparison to white sugar, honey contains large amounts of fructose and glucose. Honey also has anti microbial, antifungal, anti oxidant properties besides several medicinal properties.

Like honey, the fruits and vegetables used in this study also have therapeutic value and uses. Aonla fruit is highly nutritive and it is richest source of vitamin C. fruits are also utilized for making the Ayurvedic medicines such as chavanprash, Trifla, Amla ki Rasayan and powder, which are good for the diabetic patients. Guava is a rich source of ascorbic acid and pectin. High quality necter can be prepared from guava (Baramanry et. al, 1951). Papaya is very wholesome fruit. Aykroyed (1995) ranks it second only to mango as a source of the precursor of vitaminA. They are used in preparation of jam, soft drinks, icecreams flavouring and crystallized fruits in syrup. At last, carrot is valued as food mainly because it is a rich source of ά and β-carotene. Carrot roots are used as vegetable for soups, stews and used as salad. Carrot juice is a rich source of carotene and carrots are also canned.

In the present study honey was used as natural sweetener in place of white sugar for the preparation of various types of food products namely candy, murabba, squash, jam and toffee. Product wise recipes were finalized by determining optimal quantities of honey to be used. All the above named product were evaluated for various physico - chemical, microbial, textural (where ever required) and organoleptic characteristics in fresh (on 0^{th} day of storage) as well as during six months storage at different intervals. For shelf life studies different packaging materials and storage conditions were used. Statistical and economic analysis was worked out for all above products separately to encourage small scale entrepreneurs. Based on the results obtained from this study the most suitable conclusions are presented product wise.

It was observed that very good quality carrot candy can be prepared by mixing 750g of honey per kg of carrot.

It was also observed that fresh honey carrot candy contains 28% moisture content , 72^{o} Brix TSS, 0.064% acidity, 0.02 browning index, 30.5% reducing sugar, 78% total sugars, 16.27mg per 100g Beta carotene content.

The fresh carrot candy scored 8.33 on 9 point hedonic scale with respect to overall acceptability which decreased up to 6.83 and 6.79 respectively in glass jar and LDPE pouch during 180 days storage at ambient condition. This score corresponded to rated between 'liked moderately' to 'liked slightly'.

Honey carrot candy was found at par in various organoleptic characteristics with carrot candy prepared in sugar and jaggery syrup.

In comparison to intermediate moisture (IM) carrot preserved, the honey carrot candy scored higher for organoleplitc characteristics. Similarly in comparison to carrot milk cake the honey carrot candy was found to be at par with respect to organoleptic qualities.

Small scale industry can be established for production of honey carrot candy with production target 10kg/hr. The cost of production of honey carrot candy worked out to be Rs 52/kg. The annual net profit of Rs 2, 83,764 can be obtained with a return on investment 563% of the product is sold at the rate of Rs 75/kg.

It was observed that honey aonla murabba can be prepared by mixing honey and aonla in 1:1ratio. The score for organoleptic characteristic for such product on 9 point hedonic scale were respectively 7.85 for colour, 8.05 for flavour, 7.95 for juiciness, 8.05 for texture and taste and 7.99 for overall acceptability.

It was also observed that the fresh honey aonla murabba contained 48.33% moisture content, 52.5°Brix TSS, 6.88% acidity, 0.037 browning index, 27.3% reducing sugars, 50.4% total sugar, 152.1mg/100g vitamin C.

The physico-chemical composition and microbial characterstics were respectively found to be decreasing and increasing during 180 days storage at ambient conditions when packed in glass jar and PET jars. However, with respect to microbial characteristics glass jar proved to be a better packaging material with TPC, Y & M count being in safe limits. During 180 days storage no coliform count could be detected.

After 180 days storage the score for colour, flavour, juiciness, texture, taste and overall acceptability were respectively 7.15, 7.10, 7.77, 7.52, 6.98 and 7.31 in glass jar and between 7.37 to 6.75 for these characteristics in PET jar showing that the product was rated between liked moderately to liked slightly after 180 days of storage. However with respect to taste the product was rated between 'liked very much' to 'liked moderately'.

In comparison to sugar syrup segments of aonla, the fresh honey aonla murabba had higher vitamin C content.

A small industry can be set up for production of honey aonla murabba with the investment of Rs 48,442. With a production target of about 18kg/hr, the cost of processing worked out to be Rs 45/kg and with a sell price of Rs 75/kg. the net annual profit works to be Rs 2,63,702 with return on investment of 545%.

It was observed that honey aonla squash can be prepared by mixing 60% of aonla juice and 40% of honey.

It was also observed that fresh honey aonla squash had 35.0°Brix TSS, 0.4% acidity, 0.08 browning index , 23.7% reducing sugar, 45.5% total sugar and 78.6% vitamin C content.

The scores for organoleptic characteristic for such product on 9 point hedonic scale were respectively 7.66 for colour, 7.66 for flavour, 8.66 for taste and 8.00 for overall acceptability. This score decreased gradually during 180 days storage. The overall acceptability scores remained 6.20 and 7.05 respectively at ambient and refrigerated temperatures. This score corresponded to rated between 'liked moderately' to 'liked slightly'.

In comparison to aonla syrup the honey aonla squash has very high scores for all organoleptic characteristics. The ascorbic acid content is higher (78.6mg/100g) in honey aonla squash as compared to aonla squash (51.1 mg/100g) prepared with sugar.

The microbial counts were found to be increasing during 180 days of storage at room temperature and refrigerated temperature. However with respect to microbial characteristics refrigerated storage was better as compared to storage at room temperature with TPC, yeast and mould being in safe limits. No coli form count was detected during 180 days storage.

Small scale industry can be established for production of honey aonla squash with production target 10 lt/hr. A cost of production of honey carrot candy worked out to be Rs /lt. The annual net profit of Rs 2, 83,764 can be obtained with a return on investment of 563%.

It was observed that honey mixed fruit jam can be prepared by mixing 750 gm of honey per kg of mixed fruit pulp. The score for organoleptic characteristic for such product on 9

point hedonic scale were respectively 8.78 for colour, 8.06 for flavour, 7.63 for texture, 8.57 for taste and 8.26 for overall acceptability.

It was also observed that the fresh honey mixed fruit jam contained 48.33% moisture content, 52.5° Brix TSS, 6.88% acidity, 0.037 browning index, 27.3% reducing sugars, 50.4% total sugar, 152.1mg/100g vitamin C.

The microbial counts were found to be increasing during 180 days of storage at room temperature and refrigerated temperature. However with respect to microbial characteristics refrigerated storage was better as compared to storage at room temperature with TPC, yeast and mould being in safe limits. No coli form count was detected during 180 days storage.

Small scale industry can be established for production of honey mixed fruit jam with production target 10kg/hr. The cost of production of honey mixed fruit jam worked out to be Rs 77/kg. The annual net profit of Rs 2, 27,072 can be obtained with a return on investment 118% of the product is sold at the rate of Rs 105/kg.

It was observed that honey toffee can be prepared by mixing 400g milk powder, 120g hydrogenated fat/kg of honey.

It was also observed that fresh honey toffee contains 7.83% moisture content, 6.50 pH, 14.6% fat content,0.25 browning index, 27.99% reducing sugar and 67.43% total sugar.

The fresh honey toffee scored 8.00 on 9 point hedonic scale with respect to overall acceptability which decreased up to 6.08 and 7.50 respectively at room temperature and refrigerated temperature during 180 days storage. This score corresponded to rated between 'liked moderately' to 'liked slightly'.

Honey toffee was found at par in various organoleptic characteristics with papaya toffees

The microbial characteristics were found to be increasing during 180 days of storage at room temperature and refrigerated temperature. However with respect to microbial characteristics refrigerated storage was better as compared to storage at room temperature with TPC, yeast and mould being in safe limits. No coliform count was detected during 180 days storage.

A small industry can be set up for production of honey toffee with the investment of Rs. 1, 30,320 with a production target of 10kg/hr. The cost of processing works out to be Rs

108/kg and with a sell price of Rs 120/kg. The net annual profit of Rs 3,06,578 can be obtained with a return on investment of 227.5%.

Out of five different types of products developed in this study, Honey Carrot Candy, Honey Aonla Murabba, and Honey Toffee have found greater response from a large section of society who were served these products. Similar other products from other fruits and vegetables may be developed and evaluated.

The technologies developed in this project may be transferred to entrepreneurs for large and small scale adoptions particularly in rural areas.

Media needs to be informed about the potential use of honey in various foods. So that mass awareness of people can be created about the antimicrobial, antifungul, antioxidant and medicinal properties.

As the fruits and vegetables used in this study have therapeutic value and uses. The product developed by this study can be taken on clinical trail for combating various specific nutritional deficiencies.

The products developed in this study if properly incorporated, may lead to income generation to control poverty level and helps in overall National development.

Studies related to packaging of different products apart from method used in this study needs to be carried out in future.

Possibility of incorporation of honey in place of white sugar in development of other sweet products needs further R and D studies.

DEVELOPMENT AND QUALITY EVALUATION OF SELECTED HONEY BASED FOOD PRODUCTS

THESIS

SUBMITTED FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy

IN

HOME SCIENCE

BY

SANGEETA VERMA

Under the Supervision of

Dr. Anisa M. Durrani

Reader, Deptt of Home Science

Co-Supervisor:-

Prof. P.K. Srivastava

Ex-Chairman, Deptt of Post Harvest Engg. & Tech

DEPARTMENT OF HOME SCIENCE
FACULTY OF AGRICULTURAL SCIENCES
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

2009


Maulana Azad Library
T-7543
Aligarh Muslim University, Aligarh


T7543

Dedicated to

My beloved

Mother

&

Late Father

Dr. Anisa M. Durrani
Reader

DEPARTMENT OF HOME SCIENCE
ALIGARH MUSLIM UNIVERSITY
ALIGARH – 202002

Date: 1.4.09

Certificate

This to certify that the thesis entitled ***"DEVELOPMENT AND QUALITY EVALUATION OF SELECTED HONEY BASED FOOD PRODUCTS"*** submitted to the Aligarh Muslim University, Aligarh for the award of the degree of **Doctor of Philosophy** in **Home Science** embodies bonafide and original work of **Miss Sangeeta Verma** carried out under my supervision and guidance and that no part of this thesis has been submitted for award to any other degree or diploma.

Dr. Anisa M. Durrani
(Supervisor)

College of Agricultural Engineering & Post Harvest Technology
(Central Agricultural University)
Ranipool, Gangtok – 737 135(Sikkim)

Prof. (Dr.) P.K. Srivastava
Dean

Ph.: 03592-251381, 251359
Mobile: 09434711030
Fax.: 03592-251390
Gram: AGENGGCO
Email: dean.caepht@gmail.com

Date: 03/03/2009

CERTIFICATE

This is to certify that the thesis entitled "DEVELOPMENT AND QUALITY EVALUATION OF SELECTED HONEY BASED FOOD PRODUCTS" submitted to the Aligarh Muslim University, Aligarh for the award of the degree of Doctor of Philosophy in Home Science embodies bonafide and original work of Miss Sangeeta Verma carried out under my supervision and guidance during my tenure as Chairman, Department of Post Harvest Engineering and Technology, F/O Agril. Sciences, AMU, Aligarh during 2000-2008(Feb.) and that no part of this thesis has been submitted for award to any other degree or diploma.

Prof. P.K. Srivastava
(Co-Supervisor)

CONTENTS

ACKNOLDGEMENT

First of all, Let me thank One Universal Being – The Lord of Universe, Who out of His infinite love, bestowed and inspired the entire humanity towards knowledge, truth and eternal joy and enabled me to complete this assignment.

I feel privilege in expressing my heart - felt gratitude and indebtedness to my venerable supervisor ***Dr.Anisa M. Durrani****, Reader, Department of Home Science, Faculty of Agriculture Sciences, for her illuminative and precious guidance, keen interest and sympathetic attitude, critical opinion, which have always been a source of inspiration during the course of preparation and formation of this thesis.*

I would like to express my profound and deepest sense of gratitude and appreciation to my co - supervisor ***Prof. P. K. Srivastava*** *(former chairmen) Post Harvest and Engg. Tech. Department, Faculty of Agriculture Sciences, A.M.U. Aligarh for his constant encouragement and in valuable technical tips. He has always been kind enough in allowing me to have access to his precious time for discussion and stimulating talks despite his busy schedule and pre - occupations.*

My sincere thanks to ***Prof. Farzana Alim,*** *Chairman, Ms.Noorus Sabah Alam and Dr.Saba Khan (Lecturers) in the Department of Home Science, A.M.U. Aligarh .for providing valuable information and suggestions.*

I earnestly wish to make a special mention to ***Prof. P. Q. Rizvi,*** *Dean, faculty of Agricultural sciences and Er. Mohd Ali Khan,Chairman, Dr. Sagir Ahmad and Er. Abhay K. Srivastava (lecturers), Dr. Wazid Ali Khan, Scientist in the Deptt. of Post Harvest Engg.and Technology for their ever helpful attitude and uninstinct support.*

I must not fail in my duty to express my special thanks to Dr. M. Miyan Mirza who was always helpful to me during the entire period of completion of my thesis.

I would like to thanks my co-research scholars Mrs.Waseem Fatima, Mrs. Rafiya Bano and my junior Mrs. Anjali Rani for their continous help and support.

I wish to acknowledge the support and cooperation of office, lab and library staff of Deptt. of Home Science and Post Harvest Engg. And Technology.

Lastly I reserve my acknowledgement for my parents, bhaiya and bhabhi, my friends and my dear sister Babita and niece vishu n kirti.

Sangeeta Verma

SANGEETA VERMA

LIST OF TABLES

LIST OF FIGURES/PHOTOGRAPH

LIST OF SYMBOLS AND ABBREVIATION

ά	Alfa
@	At the rate
AD	After death
AGMARK	Grading and Marketing of Agricultural Products
AMU	Aligarh muslim university
ANOVA	Analysis of Variance
AOAC	Association of Official analytical Chemist
β	Beta
BEP	Break even point
BOD	Biological oxygen demand
CD	Critical difference
$^{\circ}$ C	Degree centigrade
Cfu	Colony forming unit
Cm	Centimeter
Conc	Concentration
EMSS	Errors mean sum of square
Engg	Engineering
Eq	Equivalent
^{0}F	Degree Fahrenheit
FDA	Food drug administration
Fig	Figure
g	Gram
GI	Glycemic index
Ha	Hectare
HAA	Heterocyclic aromatic amine
HCl	Hydro chloric acid
HMF	Hydroxy methyl furfural
Hr	Hour
IARI	Indian agricultural research institute
IM	Intermediate moisture
IU	International unit
J	Joules
Kg	Kilo gram
KMS	Potassium meta bisulphate
KVK	Krishi vigyan Kendra
KVIC	Khadi Village Industrial Corporation
Kw	Kilowatt
Kwh	Kilowatt hour
LDPE	Low density polyethylene
LPG	Liquid petroleum gas
lt	Litre

mg	milligram
min	Minute
ml	mili liter
mm	milli meter
MRSA	Methicillin Resistant Staphylococus Aureus
µg	Microgram
N	Normality
NA	Nutrient agar
NaCl	Sodium chloride
NaOH	Sodium hydroxide
ND	Not detected
NGO	Non Government Organization
nm	Nanometer
No	Number
NSS	Normal saline solution
O A	Overall Acceptability
OD	Optical density
PAU	Punjab Agriculture University
PDA	Potato dextrose agar
%	Per-cent
ppm	Parts per million
Ref	Refrigerated
rpm	Rotation per minute
Rs	Rupees
RTS	Ready to serve
SD	Standard deviation
Sec	Second
t	tonne
TA	Texture analyzer
TAHD	Texture Analyzer Heavy Duty
Temp	Temperature
TFTC	Too few to count
TPA	Texture profile analysis
TPC	Total plate count
TSS	Total Soluble Solids
USA	United states of America
Vol	Volume
Wt	Weight
W/V	Weight by volume
Y	Year
Y & M C	Yeast and Mold counts

Chapter- 1

Introduction

The word 'Honey' is derived from the Arabic word 'han'. This became 'honing' in German and 'hunging' in old English. Honey is also known as 'miel' in French and Spanish, 'honig' in Dutch, 'meli' in Greek, 'mel' in Latin, 'mej' in Hungarian, 'meile' in Italian and 'madhu' in Hindi / Sanskrit. It is used in English as a term of 'endearment'. Honey means the food derived entirely from the work of bees operating upon the nectar of flowers and other sweet exudation of plants. It shall not contain more than (a) 25% of moisture (b) 0.5% ash and (c) 5% of sucrose except in case of Carvia Callosa and honey dew where the maximum sucrose content shall be 10%. The minimum reducing sugar content (expressed as invert sugar) shall be 65% except in case of Carvia Callosa and honey dew where it shall be 60% Fructose / Glucose ratio shall not be less than 0.95 and Fiehe's test should, ordinarily be negative (Sharma, 2000).

Honey is enjoyable on account of its distinct flavour and taste. It has high viscosity, sweetness and range of colours. It is valued as a food as well as for its therapeutic attributes (Shamala and Jyothi, 1999).

Honey and its source 'honey bees' have been associated with human from the time immemorial. From the Vedic references it is well known that Indians knew about the food and medicinal value of honey because of which it was rated next to 'Amrit', the Ambrosia only. Chinese in ancient times used honey as superior medicine. Greeks and Egyptians used honey to embalm the dead bodies. It was also used as food for dead and it is reported that in tomb of a queen of Egypt, who was buried over 3000 years ago, a jar of honey was found intact in its chemical composition and its original aroma (Sharma, 2000).

Nutritionally honey is a high energy carbohydrate food considered to be best source of heat and energy giving over 3200 Kcal energy/kg. It provides wholesome nourishment as compared to other foods. The energy value of one kg of honey is approximately estimated to be equal to 19 eggs, 3 kg milk, 6.5 kg plums, 3.5 kg green peas, 5.5 kg apples or 7 kg carrots (Gopalan et.al, 2004). Being an energy rich food, it becomes a perfect food when consumed with milk.

Medicinally honey is non-irritant, promotes rapid growth of healthy tissues and is useful in pruitus value, bed sores, skin and intestinal disorders. It is very

commonly used internally in treatments of cough, cold, hey fever, gastro-intestinal disorders etc. It quickly replenishes the energy lost in various physical activities. Athletes and sportsman, mountaineers, deep-sea drivers, patients in hospitals and workers in factories are some of the special segments of society who requires the honey the most.

Honey is a versatile product that suits all occasions viz. religious ceremonies, spiritual functions, festivals and at the time of birth, marriages and even death. Infact, honey is considered as the food of foods, the drink of drinks, and drug of drugs. Being a versatile product, it is used for creating appetite, strengthening the stomach, eliminating phlegm, as a meat preservative, hair conditioner, eye salve and mouth wash.

Nutritionally, the normal consumption of honey is advised to be 10-15 g/day by children, 30-35 g/day by youth, and 30-35 g/day by healthy person, 20-30 g/day by old persons and as per advice of the physician by the patients. However, very low level of consumption of honey is reported in India (only 8.4 g/year) as compared to 120g in China, 550g in USA, 640g in Russia and 1800g in Germany (Wakhle, 1998). The main reasons for low consumption of honey in India include food habits, high cost, and utilization of major quantity for medicinal purposes.

Of resent, the production of honey in country has increased, though even then the country is placed in the last of the list of honey producing countries. The production of honey in India was reported to be 27,000 t per annum as compared to total world production of 11,70,000 t (Shamala and Jyothi, 1999). With availability of large floral sources, the country s efforts to boost honey production in last 8-10 years have started giving rich dividends and at present the bee keeping (apiculture) and honey production has become a sunrise industry in Indian states like Tamil Nadu, Uttar Pradesh, Punjab, West Bengal and Himachal Pradesh. Because of artificial bee keeping of *apis mellifera* in these states, the properties of honey produced are comparable with those of European or American honey. For increasing per capita consumption, the medicinal as well as other properties of honey viz. nutritive characteristics, antimicrobial, antiseptic characteristics etc also need to be exploited. Such utilization will provide immense benefits to the Indian population besides giving higher economic returns to beekeepers and honey processors. Because of various nutritional and therapeutic characteristics of honey, it is beneficial to promote its use either directly or through value-added products. The per capita consumption of honey

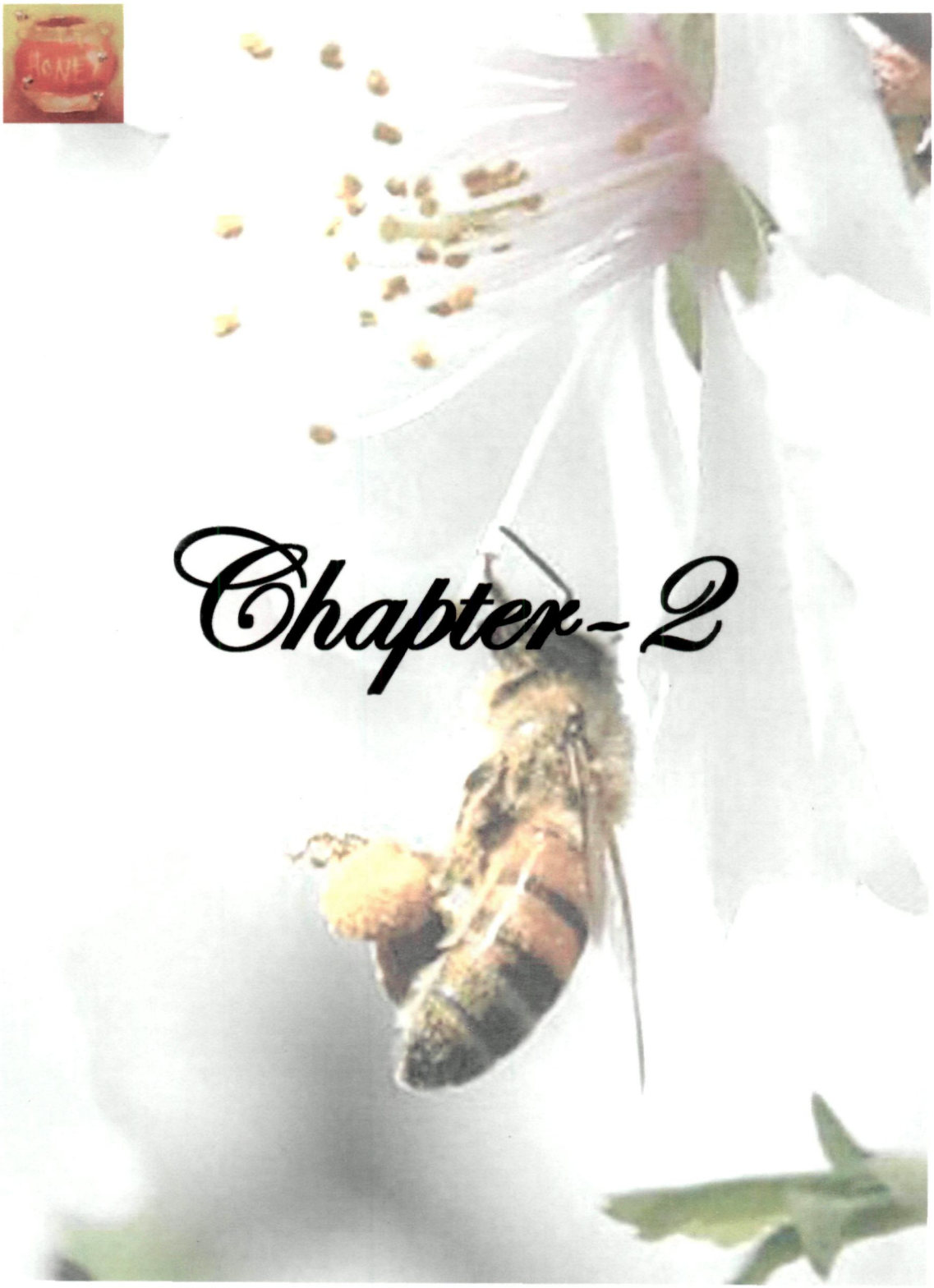
could be enhanced if its sweetness, nutritive, medicinal and preservative or antimicrobial characteristics are properly exploited and harnessed. Although, quantitatively honey is a minor sweetening agent, its unique flavour, taste, texture, healthy and wholesomeness encourages the consumers and food technologists to use honey whenever possible and applicable. The value added products of honey may include honey candy, honey powder, honey yoghurt, honey wine, honey beverages etc.

Domestically honey can be used in various forms viz honey-water, squash, spread, chikki, chocolates etc and even in the ice creams. At commercial level, it can be used successfully in bakery/baked products as well. PAU, Ludhiana has made some efforts to utilize honey in the manufacture of bread, cokkies and muffins. (Bhupinder et.al, 2003). Honey cakes can be manufactured for special occasions such as birthdays, weddings, anniversaries etc. Honey can also be commercially utilized in the manufacture of various fruits and vegetables preserves in place of white sugar or jaggery. Such products may be honey squash with lemon or mango, honey jam, honey candy, honey chocolate, honey jelly, honey murabba, honey petha, honey toffee etc. Its applications with certain fruits and vegetables viz. aonla (Indian gooseberry), carrot, chicory etc to manufacture designer foods with added therapeutic properties need some basic research related to standardization of recipes, evaluation of various characteristics viz. physico-chemical, textural, organoleptic and microbial, packaging techniques, shelf life, therapeutic values and of course economic advantages.

Informations on above aspects related to use of honey all over world are lacking in published literature. Most of the research studies in relation to processing and utilization of honey pertain to HMF (hydroxy methyl furfural) formation during storage, effect of heating on HMF and browning, influence of heating (direct heat treatment), storage temperature and period, physico-chemical and sensory qualities of Indian honey, glucose content in honey, total soluble solids (TSS), acidity, pH and standard plate count as affected by different treatments and storage conditions etc. The product development and product characteristics aspects are missing in literature. Keeping in view the above considerations the present research work was planned to develop and evaluate some promising honey based food products in which honey could be substituted in place of white sugar and which have longer shelf life. The specific objectives of the study were:

- To develop and standardize the procedures for manufacturing of selected honey based nutritional food products like honey aonla preserve, honey carrot candy, honey jam, honey chocolate/toffee and honey beverages.
- To study and evaluate the relevant physico-chemical, textural, nutritional, sensory and microbial characteristics of above developed food products.
- To evaluate the shelf life of above products in various packaging materials.
- Statistical and economic analysis for commercialization of developed products.

It is expected that the findings of this study will be utilized by various sections of society for increasing the consumption of medicinal honey as healthy food with additional advantage of ease in consumption, value-addition besides producing therapeutically advantageous designer foods with variety and taste. Such utilization will also encourage establishment of cottage industries and generate newer opportunities of income/employment generation in rural areas and enhance the economic of beekeeping in India.



Chapter-2

Review of Literature

This chapter presents detailed review of published literature on various aspects of use of honey, which are relevant to present study.

2.1 Honey

Federal Food and Durg Administration USA, has given following definition of honey: 'Honey is the nectar and saccharine exudations of the plants gathered, modified, and stored in the comb by honeybees (Apis *mellifera and A. dorsata*), is levorotatory, and contains not more than 25 per cent of water, not more than 0.25 per cent of ash, and not more than 8 per cent of sucrose' (Harry, 2001).

Thus, honey is produced by honeybees. They suck up nectar from flowers or other sweet saps found in living plants, store the nectar in their honey sac, and enrich it with some of their own substances to induce changes. When the bees return to the hive, they deposit the nectar in honeycombs for storage and ripening.

Honey production starts immediately after the flower pollen, nectar and honeydew are collected and deposited in the bee's pouch (honey sac). The mixture of raw materials is then given to worker bees in the hive to deposit it in the six-sided individual cells of the honeycomb. The changing of nectar into honey proceeds in the cell in the following stages: water evaporates from the nectar, which then thickens; the content of invert sugar increases through sucrose hydrolysis by acids and enzymes derived form bees, while an additional isomerization of glucose to fructose occurs in the honey sac; absorption of proteins from plant and bees, and acid from bee's body; assimilation of forage minerals, vitamins and aroma substances; and absorption of enzymes from the bee's salivary glands and honey sacs. When the water content of the honey drops to 16-19%, the cells are closed with a wax lid and ripening continues, as reflected by a continued hydrolysis of sucrose by the enzyme invertase and by the synthesis of new sugars.

2.2 Types of Honey

On the basis of the source of sweet liquid and also the plant species in case of floral and extra floral nectar, the honey can be classified as floral honey or dew honey. Though mono floro honeys are not common viz, honey can be categorized on the basis of floral source such as Litchi honey, Berseem honey, Eucalyptus honey, Brassica honey etc. It is also very common to name the honeys on the basis of colour.

The honey can also be classified as apiary honey and forest honey. The honey produced by hive bees, *Apis cenara indica* and *Apis mellifera* in apiaries; collected by modern extraction methods is called apiary honey. These are transparent and free from foreign materials. Forest honey includes honey produced by rock bee, *Apis dorsata* or wild nest of *A. cenara indica* in forest and collected by crude methods of squeezing the comb (Bhupinder et.al, 2004). Such honey is turbid due to presence of lot of pollen, wax, brood, and other parts of bees and plant materials.

According to recovery techniques, following kinds of honey are differentiated:

(a) Comb Honey (honey with waxy cells), i.e. honey present in freshly built, closed combs devoid of brood combs (young virgin combs). Such honey is produced in high amounts, and is widely available. Darker colored honey is obtained from covered virgin combs not more than one year old and from combs, which include those used as brood combs.

(b) Extracted Honey is obtained with a honey extractor, i. e. by centrifugation at somewhat elevated temperatures of brood-free comb cells. This recovery technique provides the bulk of the honey found in the market. Gentle warming up to 40^{o} C facilitates the release of honey from the combs.

(c) Pressed honey is collected by compressing the brood-free honeycombs in a hydraulic press at room temperature.

(d) Strained honey is collected from brood-free, pulped or unpulped honeycombs by gentle heating followed by pressing.

(e) Beetle honey is recovered by pulping honeycombs, which include brood combs. This type of honey is used only for feeding bees.

Depending upon the sucrose content honey can also be classified as natural honey and artificial honey. Natural honey is produced by honeybees while artificial honey is mostly inverted sucrose from beet or cane sugar and is produced with or without starch sugar or starch syrup. It is adjusted in appearance, odour and flavour to imitate true honey. Depending on the production method, such honeys contain nonsugar constituents, minerals, and sucrose and hydroxymethyl furfural. Artificial honey contains invert sugar ($\geq$50 %), sucrose ($\leq$38.5 %), water ($\leq$22 %), ash ($\leq$0.5 %) and, when necessary, saccharified starch products ($\leq$38.5 %). The aroma carrier is primarily phenylacetic acid, ethyl ester and occasionally diacetyl, etc. Hydroxymethyl

furfural content is 0.08-0.14%. The product is often coloured with certified food colours. Artificial honey is used as a sweet spread for bread and for making Printen (honey cookies covered with almonds), gingerbread and other baked products.

2.3 Composition

Natural honey is essentially a concentrated aqueous solution of invert sugar, but it also contains a very complex mixture of other carbohydrates, several enzymes, amino and organic acids, minerals, aroma substances, pigments, waxes, pollen grains, etc. Table 2.1 provides compositional data of honey, though the analytical data corresponds to honey from the USA, nevertheless, they basically represent the composition of honey from other countries.

Table 2.1: Composition of honey (%)

Constituent	Average value	Variation range
Moisture	17.2	13.4 - 22.9
Fructose	38.2	27.3 - 44.3
Glucose	31.3	22.0 - 40.8
Saccharose	1.3	0.3 - 7.6
Maltose	7.3	2.7 - 16.0
Higher sugars	1.5	0.1 - 8.5
Others	3.1	0 - 13.2
Nitrogen	0.04	0 - 0.13
Minerals (ash)	0.17	0.02 - 1.03
Free acids [a]	22.0	6.8 - 47.2
Lactones [a]	7.1	0 - 18.8
Total acids [a]	29.1	8.7 - 5 9.5
pH value	3.9	3.4 - 6.1
Diastase value	20.8	2.1 - 61.2

[a] mequivalents/kg

Source: H.D. Belitz and W. Grosch, 1999.

Table 2.2 shows the average composition of multifloral honey produced in four different zones of India

Table 2.2: Average value of multifloral honey produced in four zones of India.

	East zone (Assam, W.B.,Bihar)	West zone (M.S. and Mysore)	North zone (Pb., U.P. and J&K)	South zone (Kerala, Madras)	All India (Av.)
Specific gravity	1.392	1.392	1.397	1.4	1.399
Direct polarization	-2^0 6'	-1^0 9'	-1^0 9'	-3^0 27'	-2^0 20'
Moisture (%)	21.46	20.96	19.98	20.34	20.89
Total diss. Solids (%)	76.81	76.87	77.5	78.19	77.57
Reducing sugar (%)	68.91	69.97	72.78	72.88	70.24
Non-reducing sugars (%)	3.19	3.97	2.01	1.99	3.27
Levulose (%)	36.01	36.72	38.04	38.77	36.48
Dextrose (%)	32.31	33.00	35.03	34.07	33.39
L/D ratio	1.136	1.12	1.084	1.137	1.097
Dextrins (%)	2.05	1.96	2.025	1.771	1.966
Acidity (%)	0.189	0.18	0.174	0.159	0.18
Ash (%)	0.21	0.175	0.196	0.157	0.187
Proteins (%)	0.603	0.531	0.485	0.527	0.556
Undetermined (%)	2.399	2.011	2.149	1.875	2.184

The detailed composition of honey is given below:

2.3.1 Water

The water content of honey should be less than 20%. Honey with higher water content is readily susceptible to fermentation by osmophilic yeasts. Yeast fermentation is negligible when the water content is less than 17.1%, while between 17.1 and 20% fermentation depends on the count of osmophilic yeast buds. The honey produced in north Indian hot plains has less moisture content as compared to honey produced in Western and Eastern Ghats and areas with very humid climates. In these areas, the moisture levels in honey can be upto 23% and the honey is thinner in consistency. The moisture content of honey may even change after extraction or during storage due to its hygroscopic nature.

2.3.2 Carbohydrates

Fructose (averaging 38%) and glucose (averaging 31%) are the predominant sugars in honey. Other monosaccharides have not been found. However, more than 20 disaccharides and oligosaccharides have been identified (Table 2.3), with maltose predominating, followed by kojibiose (Table 2.4). The composition of disaccharides depends largely on the plants from which the honey has been derived, while geographical and seasonal effects are negligible. The content of sucrose varies appreciably with the ripening stage of honey.

Table 2.3: Sugars identified in honey

Common name	Systematic name
Glucose	
Fructose	
Saccharose	α-D-glucopyranosyl-β-D-fructo- furanoside
Maltose	O-α-D-glucopyranosyl-(1→ 4)- D-glucopyranose
Isomaltose	O-α-Dglucopyranosyl-(1→ 6)- Dglucopyranose
Maltulose	O-α-D-glucopyranosyl-(1→ 4)- D-fructose
Nigerose	O-α-D-glucopyranosyl-(1→ 3)- D-glucopyranose
Turanose	O-α-D-glucopyranosyl-(1→ 3)- D-fructose
Kojibiose	O-α-D-glucopyranosyl-(1→ 2)- Dglucopyranose
Laminaribiose	O-β-D-glucopyranosyl-(1→ 3)- D-glucopyranose
α,β-Trehalose	α-Dglucopyranosyl-β-D-gluco- pyranoside
Gentiobiose	O-β-D-glucopyranosyl-(1→ 6)- D-glucopyranose
Melezitose	O-α-D-glucopyranosyl-(1→3)-O- β-D-fructofuranosyl-(2→1)-α-D- glucopyranoside
3-α Isomaltosylglucose	O-α-D-glucopyranosyl-(1→ 6)-O- α-D-glucopyranosyl-(1→ 3)-D-gluco- pyranose
Maltotriose	O-α-D-glucopyranosyl-(1→ 4)-O-α- D-glucopyranosyl-(1→ 4)-D-gluco- pyranose
1-Ketose	O-α-D-glucopyranosyl-(1→ 2)-β-D- A-fructofuranosyl-(1→ 2)-β-D- Fructofuranoside

Panose	O-α-D-glucopyranosyl-(1→ 6)-O-α-D-glucopyranosyl-(1→ 4)-D-gluco- pyranose
Isomaltotriose	O-α-D-glucopyranosyl-(1→ 6)-O-α-D-glucopyranosyl-(1→ 6)-D-gluco- pyranose
Erlose	O-α-D-glucopyranosyl-(1→ 4)-α D-glucopyranosyl- β-D- Fructo- furanoside
Theanderose	O-α-D-glucopyranosyl-(1→ 6)-α D-glucopyranosyl- β-D- Fructo- furanoside
Centose	O-α-D-glucopyranosyl-(1→ 4)-O-α- D-glucopyranosyl-(1→ 2)-D-gluco- pyranose
Isopanose	O-α-D-glucopyranosyl-(1→ 4)-O-α- D-glucopyranosyl-(1→ 6)-D-gluco- pyranose
Isomaltotetraose	O-α-D-glucopyranosyl-(1→ 6)-[O-α- D-glucopyranosyl-(1→ 6)]$_2$ -D-gluco- pyranose
Isomaltopentaose	O-α-D-glucopyranosyl-(1→ 6)-[O-α- D-glucopyranosyl-(1→ 6)]$_3$ -D-gluco- pyranose

Source: H.D. Belitz and W. Grosch, 1999

Table 2.4: Oligosaccharide composition of honey

Oligosaccharides	**Content[a] (%)**
Disaccharides	
Maltose	29.4
Kojibiose	8.2
Turanose	4.7
Isomaltose	4.4
Saccharose	3.9
Maltulose (and two unidentified ketoses)	3.1
Nigerose	1.7
α-, β- Trehalose	1.1
Gentiobiose	0.4
Laminaribiose	0.09

Trisaccharides	
Erlose	4.5
Theanderose	2.7
Panose	2.5
Maltotriose	1.9
1- Kestose	0.9
Isomaltotriose	0.6
Melezitose	0.3
Isopanose	0.24
Gentose	0.05
3-α -Isomaltosylglucose	+ [b]
Higher Oligosaccharides	
Isommaltotetraose	0.33
Isomalyopentaose	0.16
Acidic fraction	6.51

[a] Values are based on oligosaccharide total content (= 100%) which in honey averages 3.65 %. only the most important sugars are presented.

[b] Traces

Source: H.D. Belitz and W. Grosch, 1999.

2.3.3. Enzymes

The most prominent enzymes in honey are α- glucosidase (invertase or saccharase), α- and β-amylases (diastase), glucose oxidase, catalase and acid phosphatase. Average enzyme activity in honey is presented in Table 2.5. Invertase and diastase activities, together with the hydroxymethyl furfural content, are of significance for assessing whether or not the honey was heated.

Table 2.5: Average enzyme activity in honey

S. No.	Enzyme	Activity[a]
1	α-Glucosidase (saccharase)	7.5 - 10
2	Diastase (α- and β- amylase)	16 - 24
3	Glucose oxidase	80.8 - 210
4	Catalase	0 - 86.8
5	Acid phosphatase	5.07 - 13.4

1: g saccharine of hydrolyzed by 100g honey per hour at 40^{0}C; 2:g starch degraded by 100g honey per hour at 40^{0}C. 3: μg H_2O_2 formed per g honey /h; 4: catalytic activity/g honey, and 5: mg p/100 g honey released in 24 h.
Source: H.D. Belitz and W. Grosch, 1999.

The enzymatic oxidation by- product, hydrogen peroxide, is partly responsible for a bacteriostatic effect of nonheated honey, an effect earlier ascribed to a so – called "inhibine". The enzymatic oxidation yields gluconic acid, the main acid in honey. Glucose oxidase activity and thermal stability in honey vary widely (limit values are given in Table2.4), hence this enzyme is not a suitable indicator of the thermal treatment of honey. *Catalase* in honey most probably originates from pollen, which, unlike flower nectar, has a high activity of this enzyme. Similarly, honey *acid phosphatase* originates mainly from pollen, although some activity comes from flower nectars.

2.3.4 Proteins

Honey proteins are derived partly from plants and partly from honeybees.

2.3.5 Amino Acids

Honey contains free amino acids at a level of 100 mg/100g solids. Proline, which might originate from bees, is the prevalent amino acid and is 50-85% of the amino acid fraction (Table 2.6). Based on several amino acid ratios, it is possible to identify the geographical or regional origin of honeys.

Table 2.6: Free amino acids in honey

Amino acid	mg/100g honey(dry weight basis)
Aspartate	3.44
Asparagine+Glutamine	11.64
Glutamate	2.94

Proline	59.65
Glycine	0.68
Alanine	2.07
Cysteine	0.47
Valine	2.00
Methionine	0.33
Isoleucine	1.12
Leucine	1.03
Tyrocine	2.58
Phenylalanine	14.75
β – Alanine	1.06
Lysine	0.99
Ornithine	0.26
Histidine	3.84
Tryptophan	3.84
Arginine	1.72
Unidentified Amino acids	24.53
Total	118.77

Source: H.D. Belitz and W. Grosch, 1999.

2.3.6 Acids

The principal organic acid in honey is gluconic acid, which results from glucose oxidase activity. In honey gluconic acid is in equilibrium with its gluconoactone. The acid level is mostly dependent on the time elapsed between nectar collection by bees and achievement of the final honey density in honeycomb cells. Glucose oxidase activity drops to a negligible level in thickened honey. Other acids present in honey only in small amounts are acetic, butyric, lactic, citric, succinic, formic, maleic, malic and oxalic acids.

2.3.7 Aroma Substances

About 300 volatile compounds are present in honey and more than 200 have been identified. There are esters of aliphatic and aromatic acids, aldehydes, ketones and alcohols. Of importance are especially β-damascenone and phenylacetaldehyde,

which have a honey-like odor and taste. Methyl anthranilate is typical of the honey from citrus varieties and lavender and 3,9-epoxy-1,4(8)-p-menthadiene (linden ether) is typical of linden honey.

2.3.8 Pigments

Relatively little is known about honey color pigments. The amber colour appears to originate from phenolic compounds and from products of the nonenzymatic browing reactions between amino acids and fructose.

2.4 Properties of honey

Honey varies in colour, from straw-yellow to reddish brown and even black and also in flavour depending on the floral source. Honey granulates during winter where glucose separates out in crystalline form. Granulation is a natural process and honey that has granulated can be returned to liquid form by carefully heating indirectly by keeping in hot water bath. Liquefaction is also done by heating at 65°C for 30 seconds by heat exchanger and cooling to 40°C before packing. Pressure filtration was introduced long ago (Lothrop and Paine, 1934) to eliminate crystals and fine particles of crystallization inducing substances. Granulated honey is not shelf-stable as the water content of the liquid phase increases and it becomes susceptible to fermentation.

Even though the characteristics of honey are due to its sugars, which amount to 70-80%, minor components such as pigments, acids, minerals, flavour components are also responsible for different flavours, colours and tastes of honey.

2.4.1 Physical Properties

Honey density (at 20°C) depends on the water content and may range from 1.44 (14% water) to 1.35 (21%water). Honey is hygroscopic and hence is kept in airtight containers. Most honeys behave like Newtonian fluids. Some, however, such as alfalfa honey, show thixotropic properties which are traceable to the presence of proteins, or dilating properties (as with opuntia cactus honey) due to the presence of trace amounts of dextrin.

The specific heat (20°C; 17.4% water) is 2.26 J/g/°C. Because of poor heat conductivity, the possibility of heating honey with microwaves is a viable approach. Heating 1 litre honey for 1 hr from 30 to 55°C requires 25 kW of energy (Belitz and Grosch, 1999).

2.4.2 Antimicrobial and antifungal properties

The effectiveness of honey in many of its medical uses is probably due to its antibacterial activity. It also has antifungal activity against dermophytus which cause cutaneous and superficial mycoses of humans. Definite antimicrobial effect of honey was first reported to be due to a factor called inhibine (Dold et.al, 1937). White and Subers (1963) showed that inhibine effect was due to hydrogen peroxide produced and accumulated by the action of enzyme glucose oxidase on glucose. There are many reports which deal with antimicrobial activity of honey due to various factors (Molan, 1992). Investigations have revealed that honey has bacteriocidal, bacteriostatic and antifungal activities. Growth of bacterial species such as *Escherichia coli, Staphylococcus aureus, Helicobacter pylori, Salmonella typhimurium, Shigella sps., Vibrio cholerae,* etc are controlled bacteriostatically or by bactericidal activity of honey. Nature of antimicrobial factors are due to osmotic effect, acidity, hydrogen peroxide, flavonoids, aromatic acidic substances etc. as decribed below:

Osmotic effect – Whereby water is drawn away from the microorganisms reducing their ability to survive.

Acidity – Honey is acidic, its pH ranging between 3.2 and 4.5, which inhibits growth of many pathogens. The optimum pH for growth of these species normally falls between 7.2 and 7.4.

Hydrogen Peroxide – The major antibacterial activity in honey has been found to be due to H_2O_2 produced enzymetically in the honey by the bees.

Phytochemical Factors – These non-peroxide antibacterial factors are believed to be the many complexphenols and organic acids often referred to as flavonoids. These latter complex chemicals do not breakdown under heat or light and provide honey with its 'unique' antibacterial properties. Several chemicals with antibacterial activity have been identified in honey by various researchers. These include pinocembrin, terpenes, benzyl alcohol, 3,5-dimethoxy-4-hydroxybenzoic (syringic acid), methyl 3,5-dimethoxy-4-hydroxybenzoate (methyl syringate), 3,4,5-trimethoxy-benzoic acid, 2-hydroxy-3-phenylpropionic acid, 2-hydroxybenzoic acid and 1,4- dihydroxy-benzene. However, the quantities of these are too low to count for any significant amount of activity.

2.4.3 Antioxidant Properties

Antioxidant properties of plant extracts provide considerable degree of protection to tissue against oxidative attack by neutralizing the free radicals and their generation. Types of honey like Laryngomel, Bronchomel and Dermomel collected from various herbal sources have specific medicinal properties. Laryngomel acts against laringitis, trachaitis and glossitis. Bronchomel is active against the inflammation of the upper respiratory tract, Dermomel against suppurative wounds and chronic ulcers (Rossenbalt, 1996).

2.4.4 Medicinal Properties

The earliest recorded medical prescription that included honey is dated back to about 2000 B.C. In Ebers Papyrus about 1500 B.C., seven hundred prescriptions with honey for both internal and external use have been recorded (Crane, 1996). In India, honey is used as one of the ingredients in various Ayurvedic medicinal preparations.

Results of various clinical laboratory experiments conducted by numerous researchers show that honey contains active principles of great therapeutic value which is an efficient means of combating diseases and prolonging life span. By their high nutritional quality, honey provides high degree of health to human body (Cioca, 1974). It improves the resistance of the body by improving the biological process of the organs and systems. It facilitates proteins and fat digestion and thus constitutes an excellent antidyspeptogenic factor (Andujar, 1974). Honey has tonic effect. It is medicinal property neutralizes fatigue, compensatory hypotonia, as well as the adverse effects of the other substances added when used in the preparation of beverages (Mihailesu et.al, 1974). It is very good appetizer. It is even recommended for premature babies in hypochrome anaemia and in newborn children's icterus. It acts therapeutically in vomiting babies, infections, constipation (Bifidogenic factor) and anorexy (Andujar, 1974).

Honey inherits the curative properties of plants from which it is gathered, because different kinds of honey have different therapeutic values. This difference could be due to compositions or amount of essential oils and other components which are transferred from the plants to the honey. Mimosa and Eucalyptus are found to be the best sources of antibacterial honey. The components of Mimosa and Eucalyptus find their use in phytotherapy and aroma- therapy as antiseptic and anti-inflammatory agents (Cortopassi-Laurino and Gelli, 1991). Similar effects are also found due to

essential oil principles of Geranium, Chamomile and Majoram honey. Various curative properties of honey based on different plant sources, which are actually in usage as folk medicine in France, are given in Table 2.7.

It has been confirmed experimentally that the glucoside arbutin present in bitter honey collected from the nectar of Arbutus unedo tree has great therapeutic value (Floris and Porta, 1989). This ancient Attica honey from Thymus capitatus is used as eye drops (Kalman, 1974). Honey is also used for the treatment of Mastitis in dairy animals.

Table 2.7: Honey, Sources and Curative Properties

Source of nectar	Curative properties	Particular indications
Acacia	Intestinal regulator	Intestinal statis in infants
Erica	Antiseptic (urinary tract) diuretic	Urinary tract infections and kidney insufficiency
Chestnut, Sunflower	Stimulates blood circulation	Improves blood circulation in general and vericose veins in particular
Lavender	Antiseptic, anti-inflammatory, anti-spasmodic	Diseases of the respiratory systems and arteries
Oak saps, fir tree	Anti-anaemic, antiseptic, anti-inflammatory, diuretic	Certain types of anaemia
Tiha	Anti- spasmodic, tranquilizer	Spasms of diverse origin, insomnia, epilepsy

Source: Yaniv and Rudich, 1996

2.4.5 Healing properties

When honey is applied to burns, it prevents the formation of blisters and promotes quick healing of the skin. Honey can absorb moisture and it has been prized for its mild antibiotic properties for centuries due to this fact. Where bacteria are trapped in honey, the honey will absorb moisture from the bacteria and so kill it off.

2.4.6 Cosmetic properties

A face pack can be made by mixing honey with half a cup of bran to form a smooth paste. Rosewater may be added to mix if necessary. The face pack is removed

with warm water and then a good astringent is applied. The face pack is used twice a weak to keep the skin soft, supple and free from scaliness.

Many hand and body lotions, facial creams, soaps and depilatories contain honey. It penetrates tiny crevices through which even water does not pass. It therefore makes an excellent emollient as well as a protective germ-proof shield.

2.5 Plant sources of honey in India

The bee flora in India includes Eucalyptus, Jamun , Karanja, Phalsa, Sesamum, Tamarind, Banana, Litchi, Cotton, Maize, Sunflower, Rapeseed/Mustard, Carrot, Linseed, Pigeon-pea, Pea, Chickpea, Red and green gram, Tauria, Ber, Guava, Amla, Papaya, Grapes, Mahua, Neem, Khair etc.Table 2.8 shows the flowering periods of these trees and crops.

Table 2.8: Crops and trees suitable for bee keeping in India

S. No.	Local name	Flowering period	Source of products
1	Rapeseed/mustard	Dec-Jan-Feb	Nectar+Pollen
2	Pigeon-pea(Arhar)	Sep-Nov	Nectar
3	Sunflower	April-May	Nectar+Pollen
4	Maize	May-June	Pollen
5	Jowar	Augest	Nectar
6	Bajra	September	Pollen
7	Citrus fruits	Feb-March	Nectar
8	Barseem(grass)	April-may	Nectar
9	Karanj	April-may	Nectar
10	Eucalyptus	Nov, April	Nectar
11	Seamum	April-may	Nectar
12	Jamun	May	Nectar+pollen
13	Semal	Jan-Feb	Nectar+Pollen
14	Sahajan	Feb	Nectar
15	Nashpati	Feb	Nectar
16	Litchi	March	Nectar
17	Til	September	Nectar
18	Mahua	April	Pollen
19	Babul(Deshi)	September	Nectar+Pollen
20	Aadu	Feb	Nectar+Pollen
21	Coriender(Dhania)	Feb	Nectar
22	Neem	April-Jun	Pollen
23	Aonla	April	Nectar+Pollen
24	Guava	April,Oct	Nectar+Pollen
25	Watermelon(Tarbuja)	May	Nectar+Pollen
26	Muskmelon(Kharbuja)	May	Nectar+Pollen
27	Tamarind(Imli)	April,June	Nectar
28	Cotton	Dec-Jan	Nectar+Pollen
29	Carrot	March	Nectar+Pollen

30	Raddish	March	Nectar
31	Karonda	Feb-March	Nectar
32	Amaltas	May-June	Nectar
33	Bittergourd(Karela)	July-Aug	Nectar
34	Khubani	Feb-March	Nectar
35	Shahtoot	March	Pollen
36	Rose	April-May	Pollen
37	Mehandi(Heena)	July-Sept	Nectar+Pollen
38	Khair	July-Aug	Nectar

2.6 Deterioration of quality

2.6.1 Fermentation

Fermentation of honey is caused by the action of sugar-tolerant yeasts upon the sugars dextrose and levulose, resulting in the formation of ethyl alcohol and carbon dioxide. The alcohol in the presence of oxygen then may be broken down into acetic acid and water. As a result, honey that has fermented may taste sour.

Honey with less than 17.1% water will not ferment in a year, irrespective of the yeast count. Between 17.1 and 18% moisture, honey with 1,000 yeast spores or less per gram will be safe for a year. When moisture is between 18.1 and 19%, not more than 10 yeast spores per gram can be present for safe storage. Above 19% water, honey can be expected to ferment even with only one spore per gram of honey, a level so low as to be very rare. Honey that has been fermented can sometimes be reclaimed by heating it to 66°C for a short time. This stops the fermentation and expels some of the off-flavour. Fermentation in honey may be avoided by heating to kill yeasts. Minimal treatments to pasteurize honey are as follows:

Table 2.9: Temperature and heating time chart

Temperature (° C)	Heating time (minutes)
53	470.0
54	170.0
57	60.0
60	42.0
63	7.5
66	2.8
68	1.0
71	0.4

Source: Chhuneja 2002, Ceyhan 2002 & Anonymous 2002

2.6.2 Quality loss by heating and storing

The other principal type of honey spoilage, damage by overheating and by improper storing, is related to each other. In general, changes that take place quickly during heating also occur over a longer period during storage with the rate depending on the temperature. These include darkening, loss of fresh flavor, and formation of off-flavor (caramalization).

To be of highest quality, a honey-whether liquid, crystallized, or comb- must be well ripened with proper moisture content; It must be free of extraneous materials, such as excessive pollen, dust, insect part, wax and crystal. If liquid; it must not ferment; and above all it must be of excellent flavor and aroma characteristic of the particular honey type. It must, of course, be free of off- flavors or odors of any origin. In fact, the more closely it resembles the well-ripened honey as it exits in the cells of the comb, the better it is.

The primary objective of processing of honey is to stabilize it. This means to keep it free of fermentation and to keep the desired physical state, be it liquid or finely granulated.

2.7 Processing of Honey

During process of extraction of honey from combs, bits of combs wax are incorporated in honey. Also some air borne-dust particles may be added to honey during extraction. Honey, in crude form may thus, contain some impurities such as wax, pollen, parts of bees, dirt etc and therefore needs to be processed to make it more palatable. However as honey from different sources varies in physical characteristic and chemical composition, its processing, therefore depends upon the composition.

Usually the crude honey, extracted from hives is strained through muslin cloth or sieve. It is allowed to ripen during which air bubbles also escape. In industry, the crude honey is transferred to a jacketed tin where water circulates between jacketed portion. The tin is placed on a fire or stove to heat the water. Honey is stirred continuously and its temperature is not allowed to rise above 41°C as overheating damages the aroma, flavour and colour of the honey. The bee wax is separated with strainer and honey is allowed to cool and settle. Before packaging the wax serum is removed with a knife and the honey is packed in glass bottles or cans.

For shelf-stability, honey requires further processing to avoid or minimize fermentation occurring due to high moisture and presence of yeast and to prevent

granulation. Heating is the only treatment given for processing honey. However, heat treatment, if not carefully given can lead to adverse effects. Heat may affect the honey in several ways as described below:

- Hydroxymethyl furfural is produced by degradation of honey sugars. This change also takes place during long storage at comparable higher temperature but heating is the common reason.
- Honey enzymes may be destroyed by heating.
- Heating reduces the viscosity which facilitates handling. To achieve this objective, the appropriate temperature should be between 38-43°C.
- Heating is usually employed to destroyed yeasts in honey. This honey, if not again contaminated will not ferment. The honey can be made yeast free by heating at 71.1°C for 0.4 min or at 65.5°C for 2.8 min or at 60°C for 22 minutes. Honey needs time to raise its temperature and this time is taken into account for its pasteurization.

Honey contains some crystal nuclei of dextrose. These nuclei, when very small may not be apparently visible but they are the cause of crystallization of honey. The heating destroys the crystal nuclei and thus the granulation is delayed. It can not be avoided. The general process chart of honey processing is below:

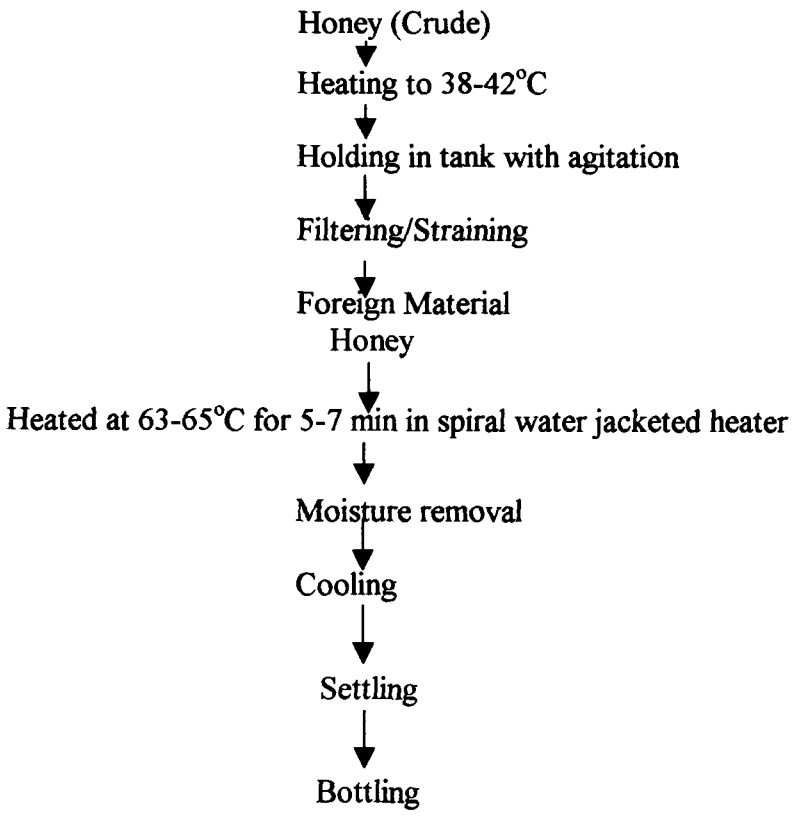


Fig. 2.1 Process chart of honey processing

In honey processing plant, crude honey is first warmed to 38-43°C to allow its easy flow. This warm honey is taken to a holding tank at about the same temperature. In the holding tank the wax and other foreign particles rise to the surface from where they are removed. The holding tank in the plant is provided with paddle type agitators. The paddles are rotated at the speed of 10 rpm while it is submerged into honey. The agitation helps in humanization and blending of honey. The agitator is rotated at slow speed so that air bubbles are not incorporated in honey. Next in line in the processing plant are the strainers, which are provided in series with decreasing mesh sizes. The minimum mesh should be around 80 mesh per inch (2.54 cm). These strainers remove all the particles. Any wax particle not removed through straining will give hazy appearance to honey. The strained honey is then passed through a tank to raise the honey temperature to 63-65°C for 5-7 minutes to destroy the yeast. This is achieved by flash heating i.e. by heating honey in thin layers. The honey so heated is quickly cooled to avoid deterioration of quality.

Honey can be dried in a spray or drum drier to produce honey powder. Honey powder is however, more hygroscopic than liquid honey.

2.8 Marketing of Honey

The honey market in India is at present much unorganized. Its major portion is collected from rock bees by the tribal using traditional methods. The apiary honey collected by modern techniques is limited to certain pockets of country and very limited organizations, institutions and cooperatives are engaged in its production, processing, procurement and marketing. In the world honey trade, India contributes less than one percent.

Marketing of honey could be made easier by improving its quality and developing remunerative pricing system. At present only apiary honey, coming from KVIC sector, which constitutes about 70% of the apiary honey is graded and marketed as 'AGMARK' products. Most of such products are purchased by Ayurvedic firms and other pharmaceuticals institutions, which purchase in bulk. Retail packaging are mostly marketed through Khadi shops.

The export of honey is still unexplored and remains to a limited extent only, that too mostly from Punjab. Interestingly the consumption and other properties of honey produced in Indo-Gangetic plains by *apis mellifera* bees are comparable with those of European or American honeys and therefore there is a great scope for

exporting Indian honey provided it is properly handled, processed and packed to meet international standards. Major emphasis should be on quality control to improve the marketing. It will be better to market centrifugally extracted apiary honey separately processed as 'table' or 'medicinal honey' whereas squeezed honey should be used for industrial purposes.

The market for royal jelly, pollen, propolis and beeswax for use as food, in cosmetic and for pharmaceuticals purposes needs to be explored as they appear to be much more dynamic.

2.9 Advantages of honey over sugar

The principal sugars present in honey are glucose and fructose. These are the simplest CHO molecules, known by their single ring structure as monosaccharides. Sucrose is the sugar that is commonly called 'sugar'. Sucrose, which is composed of fructose and glucose linked together, is a disaccharide, and comprises a little over 1% of the composition of honey. Honey contains other disaccharides, which make up over 7% of its composition. Some of the disaccharides in honey are maltose, sucrose, kojibiose, turanose, isomaltose and maltulose.

2.9.1 Sweeter than Sugar

Fructose is slightly sweeter than sucrose, glucose is less sweet, and maltose even less sweet. In most honeys, fructose predominates and trends to make honey taste slightly sweeter than sugar. Some honeys, which are rich in fructose, tend to taste very sweet, but there are a few types of honey, which contain more glucose than fructose. With regard to taste, fructose is approximately 1.7 times sweeter than sucrose and 2.3 times sweeter than glucose. Because fructose is sweeter than sucrose or glucose, less fructose is required for the same sweetening effect.

2.9.2 Honey Substitutions chart

The honey substitutions are all on a total solids basis. On a sweetening basis, honey is about 25% sweeter than sugar or sucrose due to its fructose content (about 38.5g fructose per 1,000g honey). Values listed below are based on averages and may vary.

(i) Sugar- Honey Substitution (gram basis)

1. Sucrose(dry)	100% solids, 0%water
2. Honey	82.4% solids, 17.6% water
3. 1,000 g sucrose	1,000 g solids, 0 g water
4. 1,000 g honey	824 g solids, 176 g water

Conversion factor:

1,000g solids in 1,000g sucrose/ 824g solids in 1,000g honey = 1.2135922. To replace 1,000g sucrose with honey, use 1,214g honey and subtract 214g of water from the total formula.

(ii) Liquid Sucrose- Honey Substitution (gram basis)

1. Liquid Sucrose	Average 67.5° Brix 67.5% solids, 32.5% water
2. Honey	82.4% solids,17.6% water
3. 1,000 g liquid sucrose	675 g solids, 325 g water
4. 1,000 g honey	824 g solids, 176 g water

Conversion factor:

675g solids in 1,000g liquid sucrose/824g solids in 1,000g honey = 0.8191748. To replace 1,000g liquid sucrose with honey, use 819g honey and add 181g of water to the total formula.

(iii) Liquid Invert Sugar- Honey Substitution (gram basis)

1. Liquid invert sugar	Average 76.55° Brix 76.55% solids, 23.45% water
2. Honey	82.4% solids,17.6% water
3. 1,000 g liquid invert sugar	765.5 g solids, 234.5 g water
4. 1,000 g honey	824 g solids, 176 g water

Conversion factor:

765.5g solids in 1,000g liquid invert sugar/824g solids in 1,000g honey = 0.9290049. To replace 1,000g liquid invert sugar with honey, use 929g honey and add 71g of water to the total formula.

2.9.3 Energy

Honey is more concentrated than table sugar, so honey packs more energy punch when measured spoon for spoon against sugar i.e., one tablespoon of honey has 65 calories, compared to the 45 calories in a tablespoon of granulated sugar. In other words, 1 tablespoon of honey, based on caloric value, is equal to 13/4 tablespoon corn syrup, 4 tablespoon maple sugar, 11/2 tablespoon molasses etc.

2.9.4 Digestion

Honey is far easier on the digestive system than refined sugar. As sugar molecules in honey can convert into other sugars (e.g. fructose to glucose), honey is easily digested by the most sensitive stomachs, despite its high acid content. It helps kidneys and intestines to function better.

"Honey is a perfect food. It contains large amounts of vitamins, minerals, being particularly rich in vitamin B and C. It contains almost all vitamins of the B-complex, which are needed in the system for the digestion and metabolism of sugar" (Saxena and Jaiswal, 2005).

2.9.5 Diffusion through the blood

The basic sugar type in honey are more easily assimilated into the bloodstream and thus yield their energy giving properties more quickly and efficiently than with white sugars. The glycogen in a spoonful of honey is said to pass into the bloodstream in ten minutes to produce this 'quick energy'. When accompanied by mild water, honey diffuses into the bloodstream in 7 minutes.

Many people refrain from using honey in the belief that it is high in calories and may cause unwanted weight gain. An average teaspoon of honey contains only around 25 calories, and as mentioned above it converts quickly and efficiently into 'energy', unlike white sugar.

Its free sugar molecules make the brain function better since the brain is the largest consumer of sugar, thus, it reduces fatigue.

2.9.6 Beneficial in maintaining blood sugar levels

According to Dr. Richard Kreider, "honey appears to be a carbohydrate source that is relatively mild on its effects upon blood sugar compared to other carbohydrate sources". (Saxena and Jaiswal, 2005).

Glycemic index (GI) of fructose is much lower than those of glucose or sucrose. In fact, fructose is known to have the lowest GI of any of the sugars, and

little or no increase in blood sugar is noted after ingestion of large amounts of fructose (Mann, 1987). This fact has led to the promotion of fructose as the preferred sugar source for diabetics (Uusitupa, 1994).

2.10 Other benefits and uses of honey

2.10.1 Antioxidants

Antioxidants are important in their ability to fight toxicity in the bloodstream and may help fight off harmful infections. Thus, it plays an important role in the prevention of cancer as well as heart diseases. Honey contains antioxidants, which are non-nutritive agents that decrease the activity of cell-damaging free radicals linked with many chronic diseases. In particular, darker varieties of honey can contain large quantities of a particular antioxidant called flavonoid, the same agent found in red grapes that have been credited with leading to lower instances of heart disease among wine drinkers.

Honey's antioxidants can also make cooked meat safer. When meat is cooked its fats release potentially dangerous free radicals, which can attack the body's cells. But Dr. Engeseth found that adding one teaspoonful [5g] of honey to 100 g of meat before cooking helps block these free radicals, and improves the smell and taste of meat. (Saxena and Jaiswal, 2005).

2.10.2: Supports blood formation

Honey provides an important part of the energy needed by the body for blood formation. In addition, it helps in cleaning the blood. It has some positive effects in regulating blood circulation. It also functions as a protection against capillary problems and arteriosclerosis.

2.10.3: Antimicrobial Activity

Roydon Brown in his book 'Bee Hive Product Bible' provides invaluable insight into the properties of bee products. He writes about the use of honey to treat respiratory ailments, and relates to exhaustive research conducted in Bulgaria: " He found honey has bactericidal, anti-allergenic, anti-inflammatory and expectorant properties that insure the body an immunobiological defense and give it the capacity to regenerate its attacked cells" (Saxena and Jaiswal, 2005).

One antioxidant in particular, pinocembrin, which is unique to honey, is currently being studied for its antibacterial properties. According to the research, honey's high sugar content slows bacterial growth by reducing the amount of water

available to them. In addition, an enzyme secreted from the bee's mouth makes hydrogen peroxide, which acts as an antimicrobial agent when diluted with water. Honey's acidity also has antibacterial properties. Thus, honey can be used for:

(i) Helping in Healing Wounds

There are several factors that may account for honey's healing properties; Bacterial infections require water to thrive. The sugars in honey attract water, and may deprive the bacteria resulting in diminished activity from the virus.

Bee pollen and propolis enzymes are present in even the purest of row honey. These possess antiviral and antibacterial properties that work from within the honey to sterilize wounds and assist healing.

Glucose oxidase found in honey combines with water and produces hydrogen peroxide. Hydrogen peroxide has antiseptic properties.

(ii) Treatment of Diarrhea

Honey promotes the rehydration of the body and more quickly clears up the diarrhea and all kind of vomiting and stomach upsets. The antibacterial properties of honey, both the peroxide and non-peroxide, are effective in the laboratory against MRSA strains of bacteria, which are notoriously resistant to antibiotics and are sometimes responsible for the closing of hospital wards.

(iii) Treatment of Ulcers

In Europe, honey has been used internally to help cure ulcers, particularly stomach ulcers. The advantage of honey is that it not only prevents infections from occurring, it also actually accelerates skin healing. Since the sugar in honey absorbs water it helps to trap some of the moisture so that the bacteria and other microbes can't grow as easily as in other food.

(iv) Treatment of Wounds

Due to its natural anti-inflammatory effect, honey helps to heal the wounds more quickly. It also has different phytochemicals-chemicals found in plants and different foods-that kill viruses, bacteria, and fungus making it a good substitute for wound dressings.

2.10.4 Protects teeth

Many people think that because honey is sweet it is bad for our teeth, but research shows that it actually helps fight tooth decay.

Studies at the University of Chicago Dental School (Sexena and Jaiswal, 2005) shows that compounds in honey, particularly the darker honeys, attack the bacteria, which can rot teeth.

2.10.5 Good for Skin

It has the ability to attract water. It is also safe for sensitive skin. People can also use it as a moisturizing mask for their skin as well as their hair. To use it as a conditioner, the honey is mixed with olive oil. However the hair need to be washed thoroughly afterwards.

2.10.6 Honey in food preservation

Honey possesses numerous functional characteristics that can improve the quality of a variety of food products. In meat products honey can enhance the meat flavours, bind ingredients and act as a culture substrate in cured products. Honey may also improve the cook yield in poultry meats by adding to the overall weight. In addition, honey contains large amounts of reducing sugars, which can participate in the Maillard reaction along with the amines found in poultry meats. Finally, because of honey's unique antioxidant profile it may serve as an effective means of inhibiting foodborne pathogens, reducing hetrocyclic aromatic amine (HAA) formation, and stabilizing lipid emulsion systems such as salad dressings (Mundo et.al, 2004).

2.10.7 Food uses of honey

For curative purposes, honey gives best results when taken in its natural form or diluted with water/mineral water, eaten with bread, milk, cereals or fruits. Honey improves the taste and increases the calorific value and digestibility of dishes. It can also be used as a substitute for sugar used for making jellies, stewing fruits, making vitaminised drink and other nutritious beverages. Honey cakes, honey cookies and biscuits made with honey have pleasant flavour and are much more nutritious than many of sugar based products (Singh et.al, 1988).

2.10.8 Medicinal uses of honey

Honey is mankind's oldest food and medicine. Honey is a universal medicine while the other bee products viz. royal jelly, propolis, bee pollen, wax and venom have specific uses.

Following are some tips from the world of apitherapy (medicine from bees) to reduce medical bills.

(i) Honey for burns

Honey may be applied freely over burns. It cools, removes pain and aids fast healing without scarring. Apart from being a salve and antibiotic, bacteria cannot live in honey.

(ii) Bed Wetting

A teaspoon of honey before bed, aids water retention and calms fears in children.

(iii) Sleeplessness

A dessert spoon of honey in a mug of hot milk aids sleep and works wonders.

(iv) Nasal Congestion

A dessert spoon of honey is placed in a basin of hot water and its fumes are inhaled after covering head with a towel over the basin. It will be very effective in checking nasal congestion.

(v) Sore Throats

A teaspoon of honey is melted in the back of the mouth and allowed to trickle down the throat. This activity eases inflamed raw tissues.

(vi) For Stress

Honey in water is a stabilizer- calms highs and raises lows. Approximately 25 percent honey is mixed in water for this purpose.

(vii) Anaemia

Honey is the best blood enricher by raising corpuscle content. The darker the honey the more minerals it contains.

(viii) Heart Patients

Heart patients are advised to replace white sugar (sucrose) with honey, natural fructose and glucose.

(ix) Osteoporosis

English research has shown that a teaspoon of honey per day aids calcium utilization and prevents osteoporosis. It is essential from age 50 onwards.

(x) Long life

One common fact worldwide is that the most long-lived people are regular users of honey. An interesting fact yet to be explained is that beekeepers suffer less from cancer and arthritis than any other occupational group worldwide.

(xi) Migraine

A dessertspoon of honey is dissolved in half a glass of warm water and siped at the start of attack. If necessary this process is repeated in 20 minutes. This process is always effective (so tip goes) as migraine is stress related.

(xii) Conjunctivitis

Honey dissolved in equal quantity of warm water, is applied as lotion or eye bath (Russell's, 1983).

2.11 Use of honey in food industries

Honey is largely used on a small scale. It is also used in an industrialized level in baked products, confectionery, candy, marmalades, jams, spreads, breakfast cereals, beverages, milk products and many preserved products.

Natural, health and biological products use honey abundantly as a sweetener of first choice, together with non-refined sugars substituting for refined sucrose. In fact, honey can substitute all or part of the normal sugar in most products. Limitations are presented on one side by costs and handling characteristics and on the other by the natural variations in honey characteristics, which change the end product, making it more variable and requiring more frequent adjustment in the industrial formulation (Sexena and Jaiswal, 2005).

2.11.1 Use of Honey in Bakery Product

Judicious uses of honey in bakery products have several advantages (Glade et.al, 1980), but incorporation of high level of honey solids in specialty breads, exerts a diluting effect on flour proteins, resulting in lower volume and poorer bread texture. Addition of vital gluten improves the texture at the expense of increased mixing and fermentation time. Certain dextrin products are gluten functional in that they facilitate the protein-water reaction in mixing and thus, reduce the mixing time of dough containing high levels of honey solids. Baking test has also demonstrated that the volume of loaves was significantly increased when dough containing 14% honey solids and added gluten were supplemented with dextrin. Higher levels of honey can also be incorporated into honey-based bakery products using dried honey (Laftsidis S, 1970). Long life bread that keeps its texture and flavour for more than 10 days at normal temperature can be made by the incorporation of honey (Candert P, 1971).

A blend of honey and invert sugar for the production of bread offers many advantages (Voll, 1974), such as excellent fermentability (high level of gas

production) and pH behaviour in the continuous mixing process which eliminates handling problems. The quality of the bread produced using a honey, invert sugar blend, is equal to that produced using liquid honeys, in both the above mentioned and continuous mixing process.

Stiffening of usual dough ingredients in the presence of sweetening agents like honey for the production of baked products based on rye or wheat flour like breakfast cakes, ginger bread etc considerably shorten the proofing time. Honey based pastry has also been attempted. An industrial confectionery product based on honey in its natural state can also be manufactured (Ramsey et.al, 1933). Honey is used as an adhesive and the sweet is covered with a chocolate or crystallizable sugar coating.

Honey is employed in various types of ready to eat cereal products. Honey graham can be prepared by partially cooking a syrup comprising liquid honey and sodium bicarbonate together with wheat flour (Fast et.al, 1971). The partially cooked product Granola, a ready-to-eat cereal product marketed in some countries, made by grinding biscuits made from wheat meal, oat meal and maize, has provided an additional example of honey uses (Colangelo K,1980). Wheat, maize, rice, oat are the cereals generally used for the preparation of flaked and puffed products. These products use a sucrose syrup containing 1-8% of these sugars, for example honey which provides a hard transparent coating that does not become sticky even under humid conditions.

Use of dry honey as a replacement for liquid honey in cookies require a shorter baking time [(12 min at 350°F against 14 min) (Laftsidis S, 1970)]. Such cookies were of even colour, with more pronounced honey flavour but those from liquid honey were not commercially acceptable (Schmidt M, 1978). The honey can be used for the preparation of good quality waffers also. Honey is the optimum sweetening agent according to the FDA standards of identity for fruit butters, jellies, jams and preserves, providing or represent 20% of the solids in mixtures with certain other optional sweeteners.

2.11.2 Use of honey in beverages

The inclusion of 2-3% honey in prune juice has gained some recent success. Attempts to prepare beverages or beverage bases containing lemon juice and honey have been retarded by the formation of an unsightly floc during storage, which can be eliminated by treatment with bentonite. It is also used as a sweetening agent in tea.

Iron in honey interact with tannins in the tea to give darkened colour. This particular reaction is observed when iron content of honey is 42ppm (Dondel and Jaclesen, 1980).

Recently, the use of honey in clarification of apple juice has been made with concentration as low as 4% of honey alone. Honey treatment is found to act in combination with pectinase to produce a significant effect upon flocculation. The combined treatment of honey with enzyme is found to induce fast flocculation than enzyme alone at cold as well as warm temperature. When used alone honey treatment produces a clarified juice with a viscosity similar to that of cider (Mc Lallan et.al, 1985). Sun dried and freeze dried fruit extracts can be blended with finely crystallized honey to produce spread with a sweet sour, honey fruit flavour. The variety and form of the fruit, along with the particle size and concentration, influences the end product. Commercial production of this type of product is feasible and economical. High density honey fruit spreads have also been prepared by mixing high solid fruit juice concentrate with 5 to 8 parts full density honey, followed by controlled crystallization (Berthold et.al, 1968). Honey can be used (atleast 5%) in the manufacturing of sweetened peanut butter spread which has sufficient shelf life (Billerback et. al, 1976).

2.11.3 Use of honey in confectionary production

Confectionary production includes honey. For the production of caramels, honey is only used in small quantities since it's hygroscopicity (ability to absorb moisture) presents a major disadvantage. It reduces the preservation time and soften the caramels at the surface, causing them to stick together. Candy bars often use honey as a binding and sweetening agent. The bar ingredients are chopped to various sizes and mixed with the hot honey and sugar. Depending on the composition and the degree of heating of the sugars (including honey), a more or less solid product is obtained after cooling. In any case, all such products are fairly hygrocopic and need to be packed with material impermeable to moisture.

Ice-cream sweetened with honey never had much commercial success (except in Italy), since it melts more easily and at lower temperature than those made with sugar. This difference makes it difficult to distribute ice creams made from different sweeteners together. In other countries, honey based ice creams are marketed successfully when it is sold in pre-packaged individual portions or larger 0.5 to two

litre containers. The addition of more than 7.5 percent honey softens the ice-cream significantly, due to its lower freezing point (Saxena and Jaiswal, 2005).

2.11.4 Use of honey in tobacco industry

The tobacco industry uses honey to improve and preserve tobacco's aroma and humidity (Saxena and Jaiswal, 2005).

2.12 Ancillary Industries

A number of small scale industries depend on honey production, processing and utilization. These provide lot of avenues for income and employment generation in rural areas. These include honey based industries, bee wax industries, bee venom based industries, royal jelly based industries etc besides bee keeping and processing industries and equipment manufacturing industries. Some of these are described below:

(A) Honey based industries

Industries may be set up for utilization of honey products. Some examples are:

- Honey used in pharmaceuticals and other industries: There is a lot of demand for honey in medicinal preparation, in baking, confectionary, food industries, cosmetics and veterinary activities. Honey and bee wax serve as ingredients in many creams and lotions of fine quality.
- Honey used in meat industry: Honey is also used in meat packaging. USA alone consumes 75-100 tonnes of honey per year for this purpose.

(B) Bee wax industries

Several pharmaceuticals industries are large users of bee wax. These include shoe and floor polish, wax modal, tapes, insulating tapes, dentistry coating, lithography, engraving, ammunition and water proofing materials manufacturing industries.

(C) Bee venom industries

Bee venom is used in treatment of rheumatics, neuralgia, skin diseases and goiter etc.

(D) Royal jelly industry

It is used in improving digestive system and helps in gaining weight and in curing ulcers. It is also used to prevent aging.

(E) Equipment and hives manufacturing industries

Several small scale industries could be developed in rural areas to fabricate and sale bee hives, honey extractors, honey containers, bee veils, bee gloves, wax extraction, smokers and other items used in bee keeping and honey production and processing.

2.13 Quality and Grades

An insignificant amount of honey is marketed in India under Agmark grades, which are dependent upon the presence of moisture in the honey, as described below:

- Special grade Moisture Less than 20%
- A grade Moisture Less than 22%
- Standard grade Moisture Less than 25%

A standard honey must fulfill the compositional criteria, as presented below:

- Moisture content not more than 21%
- Apparent reducing sugars content not less than 65%
- Apparent sugar content not more than 5%
- Water soluble solid content not more than 0.1%
- Mineral content (Ash) not more than 40mg eq
- Acidity acids per kg
- Fructose/glucose ratio not less than 0.95%
- Diastase and hydroxy methyl furfural content not less than 8%
- Fieche's test and Aniline chloride test should ordinarily be negative.

2.14 Problems faced by Indian honey Industry

There are some problems, which were faced by Indian honey industry:

- As bee keeping is not an organized village industry in India, it is very difficult to collect authentic data, right from the levels of beekeepers to the state and national level organization. This results in poor marketing of honey. A modern computerized information system needs to be developed to link local cooperatives, NGO's, Honey producers associations, private organizations and state level development agencies with some central organization.
- In absence of any National level Honey policy of Government, the honey production (beekeeping) and processing industry could not keep pace with the overall

industrialization process in the country. This has also affected the quality control and trading of honey and its products in international markets.

- The unorganized nature of internal marketing and export of honey has been responsible for uneconomic domestic and international price structure and the resulting exploitation of beekeepers.
- The various stake holders namely leading beekeepers, government and non-government agencies have not taken interest in extraction, utilization and export of other honey products like pollen, royal jelly, propolis, bee venom, etc. which have higher export potentials.
- The modern processing facilities for honey products in country are insufficient and as greater production of honey and its procurement cells for greater processing capabilities. The government can encourage the NGO's and self help groups in, setting up more modern processing plants.

2.15 Scope of Medicinal Honey

Using sources of nectar from medicinal plants having active compounds, medicinal honey's production could be increased. In this reference mention may be made of aromatic plants belonging to the family *Labialae Salvia officinals* and *S. fructicosa, Cordio-ltymus* and *Majorna syriaca,* which are the sources of high essential oils and the honey of which are known for the treatment of colds, inflammation and indigestion. *Crataegus oxycantha* is prescribed as cardiac depressant and as a hypotensive. *Retarna raetam,* a desert plant is used for curing rheumatic pain and external wounds and also has a potential application in cancer treatment. *Echinacea angustifolia* is used for strengthening of immunity (Yaniv and Rudich, 1996). The best could also be made to feed on the sweetened plant extract of plant parts such as roots, stems, leaves and flowers, based on the high content of active compounds (similar to feeding of sugar solutions at times) for the production of high quality medicinal honey, thus offering a new avenue into natural medicine.

2.16 Honey Based Fruits and Vegetable Products

Sharma (2000) has described following honey based fruits and vegetable products:

2.16.1 Honey with fruits

(a) Raspberries- Raspberries (*Rubus idaeus L.*) have been known to possess curative properties since antiquity when its dried berries were used to treat fevers and an infusion of its flowers was considered an antidote for snakebite. Dried raspberries are

viewed as a most effective diaphoretic during colds. Its efficacy is increased with honey. Raspberry juice with honey is a refreshing beverage.

(b) Apricots- Fresh juice of apricots, mixed with honey, is a very cooling drink during fevers. It quenches the thirst and eliminates the waste products from the body. It tones up the eyes, stomach, liver, heart and nerves by supplying vitamins and minerals.

(c) Indian gooseberry- The juice of Indian gooseberry, mixed with honey, is useful in preserving eye sight. It is also reported to be beneficial in the treatment of conjunctivitis and glucoma. It reduces intra-ocular tension in a remarkable manner. A cupful of this juice mixed with honey should be taken, twice daily in such cases.

(d) Lemon juice and honey- It is a good remedy in case of hypertension, insomnia and nervous disorders. Dissolve a spoonful of quality honey in a glass of mineral water and add the juice of half a lemon. The beverage is pleasant and nutritious. Lemon juice with honey and olive oil is good in complaints of the liver and gall bladder. For a bad cold, the juice of two lemons in half a litre of boiling water, sweetened with honey taken at bed time, is a very effective remedy. Though the lemon juice is sour in taste, its reaction in the body is valuable in the treatment of gout, rheumatism, lumbago, pain in hip joints, which result from too much acid in the body. A sufficient intake of lemon juice prevents the deposit of uric acid in the tissues and thus, reduces the possibility of an attack of gout. Lime has proved effective in the treatment of acute tonsillitis. A fresh lime squeezed in a glass of warm water, with four teaspoonful of honey and a quarter teaspoonful of common salt, should be sipped slowly in such cases. Fresh juice of lime mixed in glassful of water and sweetened with honey should be taken every morning on empty stomach in case of obesity.

(e) Herbal Tea- Mixture of tulsi, rose, liquorice, brahmi, lungwort and honey is good for cough in illnesses affecting the respiratory tract. A tablespoon of the herbal mixture is steeped in a litre of boiling water for 3 to 4 hrs. One to two cups of the tea are drunk daily with a teaspoon honey. Fairly strong, warm tea, taken with lemon, black pepper and honey is an effective diaphoretic for treating catarrhal illness of the respiratory tract, and diuretic. Mixing of honey improves the medicinal value of tea.

(f) Linseed Tea- Linseed tea with aniseed, fennel and honey as an effective laxative. A teaspoonful of the mixture is boiled with 250 g of water for 3 to 4 min. using ground linseed, fennel, pharmaceutical dill and good quality of honey.

(g) Amla- The dry fruit is useful in diarrhoea and dysentery. One tablespoon full of the paste of leaves mixed with honey or buttermilk also makes an effective medicine in the treatment of diarrhoea and dysentery.

(h) Jamun fruit- Fresh jamun fruit taken with honey is also an effective medicine for bleeding pile.

(i) Mango Kernels- Honey mixed with powder of mango kernels is good for treating bleeding piles.

(j) Honey in orange juice for heart disease- Orange juice sweetened with honey is highly beneficial in heart diseases, cardiac conditions like coronary ischaemic and infaraction, when only liquid food is advisable. The use of orange juice with honey is a very safe energy giving liquid food. The use of orange juice mixed with a pinch of salt and a tablespoonful of honey is an effective food remedy for tuberculosis, asthma, common cold, bronchitis and other condition of cough.

(k) Papaya- (for treating Roundworms) The digestive enzyme papain in the milk of the unripe papaya is powerful antihelimintheric (power to destroy roundworm). A table spoonful of the fresh juice and equal quantity of honey should be mixed with 3 to 4 tablespoon of hot water when taken as a dose by an adult. Papaya seeds with honey are also useful for this purpose, they are rich in a substance called "Caricin" which is a very effective medicine for expelling roundworms.

(l) Pomegranate- Pomegranate juice is an appetizer, a digestive food item and is useful for patients suffering from colitis and mucus. It binds the stools and tones up intestines. A tablespoonful of the juice mixed with equal quantity of honey can be given with beneficial result in bilious vomiting i.e. bile containing fluid and nausea burning in chest due to excessive secretion of bile, flatulent colic and morning sickness. The juice of the fruit with honey is useful. A juice of this with honey is beneficial in the treatment of typhus, gastric and asthmatic fever.

2.16.2 Honey with vegetables

(a) Asparagus for heart disease-The asparagus is an excellent food for strengthening the heart. A good medicine for weak or enlarged hearts is prepared by mixing the freshly expressed juice of this vegetable with honey and taking a teaspoonful three times daily.

(b) Beetroot for digestive disorder-Fresh beet juice mixed with a tablespoonful of honey taken every morning before breakfast helps the healing of gastric ulcer.

(c) Mint for respiratory disorders- A teaspoonful of fresh mint juice, mixed with two spoonfuls of pure malt, vinegar and equal quantity of honey is stirred in four ounces of carrot juice and is given thrice daily as a medicated tonic during the treatment of tuberculosis, asthma and bronchitis.

(d) Radish- Radish juice (Raphanus sativa) with honey is in the form of ready-to-serve drink (100g to 400g a day) prevents the formation of stones in bladder and kidneys. It helps to prevent arteriosclerosis, dropsy and is also considered good for cough and hoarseness as it stimulates the secretion of sputum. A syrup prepared by mixing tea spoonful of fresh radish juice with equal quantity of honey and a little rock salt is highly beneficial in the treatment of hoarseness, whooping cough, bronchial disorders and other chest complaints. It should be given thrice daily.

(e) Tomato for intestine and liver disorders- A glassful of fresh tomato juice, mixed with a pinch of salt, pepper and one teaspoonful of honey, taken early in the morning is considered an effective remedy for morning sickness, sluggishness and diminished responsiveness of the liver, indigestion of gas in the intestines, constipation, diarrhoea due to indigestion, burning in the gastro-intestinal tract and constant burning sensation in the chest due to hiatus hernia, a condition in which stomach passes partly or completely into chest. A glassful of fresh tomato juice mixed with honey, a pinch of powdered cardamom seeds, taken after swallowing three peeled cloves of garlic every night before going to bed, is considered highly beneficial in the treatment of tuberculosis and other lung infections. In asthmatic, it reduces the congestion in the bronchioles, and checks hyper-secretion of mucus and reduces the spasms.

2.16.3 Honey based common products

(a) Honey Biscuits

Honey	— 100g
Egg	— 2-3 Nos.
Bicarbonate of soda	— 1 teaspoon
Cinnamon	— 1 teaspoon
Sugar	— 5 Tablespoons
Butter	— 1 Tablespoon
Cloves	— 1 Tablespoon
Shredded dried pea	— One lemon
Plain Flour (to make a thick dough)	— 10 cups

Make a syrup of the sugar and honey. Add flour to hot syrup and whisk together quickly to a thick consistency. Allow the mixture to cool at room temperature and add the softened butter and soda (previously mixed with one tablespoon of flour) and the shredded dried lemon peel. Knead for 15-20 min., and then roll out to a thickness of one centimeter. Cut into pieces or shapes. Place the biscuits on a greased baking sheet and brush with white of egg. Bake in a moderately hot oven.

(b) Honey cake

Honey	— 1 kg
Sugar	— 1 cup
Butter	— 2-3 tablespoon
Flour	— 4 cups (plain)
Egg	— 4-5 Nos
Bicarbonate of soda	— 1/2 teaspoon
Cinnamon	—1/4 teaspoon
Clove to taste	

Bring the honey, butter, and sugar to the boil. Remove from the flame, add the flour, and knead the dough. Allow the mixture to cool then add the eggs, bicarbonate of soda, clove, cinnamon, and mix together thoroughly. Set the dough to stand in a cool place on a greased baking sheet and bake in a fairly hot oven.

(c) Honey Oat Cake

Honey	— 100 g
Flour	— 1 cup
Oats rolled	—1/4 cup
Sugar	—1/2 cup
Sour cream	—1/2cup
Bicarbonate of soda	— 1/2 cup
Butter	— 100 g

Mix the flour and soda. Cream the butter and sugar together until white, while beating add honey, sour cream, egg, rolled oats flour and soda. Roll out thin (3-5mm), cut into various shapes, and bake in a hot oven (400° F-425° F) for 10-15 min.

(d) Honey Puffs

Honey	— 100 g
Icing sugar	— 100 g to 150 g
Egg	—2 Nos

Bicarbonate of soda — 1 teaspoon

Vegetable oil, several} — 200 g

Cloves, Ground Flour

Mix the honey with icing sugar and warm. Add vegetable oil, eggs, soda and clove. Beat the mixture, gradually stirring the flour until the dough is fairly thick. Form into balls a little larger than a hazelnut. Bake in a moderate hot oven.

(e) Honey Drinks and Beverage—Honey drinks are enjoyed nationally and internationally in folk tales and legends. The story of their preparation is age old, and both ancient and modern poets and writers have devoted fine passages to it. Greek mythology tells that Zeus, the king and ruler of the gods, was taught how to make a delicious wine from it. With the help of his mother Reha, Zeus saw to it that his father Capronos drank heavily of this honey wine, and unsurped the throne while cronos was sipping-off. The wine made from honey is called Mead.

(f) Honey Cocktail

Milk — 2 cups

Orange juice — 1/2 cups

Honey — 6 tablespoon

Egg — 1

Brandy — 60 g

Beat the egg until thick and add salt to taste. Add the beaten egg and honey to the cold milk, then the brandy and orange juice serve in tall glasses with straw. Make three to four portions.

(g) Honey Table Beverage

Boiled water — 1 cup

Honey — 25 g

Citric acid — 1 g

Add honey to hot water and boil for 4-5 min. then add citric acid. Strain and serve cold.

(h) Aonla Honey Jam

Fresh aonla fruits are washed, grated and filled in a clean glass jar. Honey is poured to fill the jar. This jar is now kept in sun for 4-5 days (no cooking) which result in an aonla jam with maximum nutritional and medicinal value.

(i) Blackcurrants and Honey

Blackcurrants are rich in vitamins, provitamin A (carotene), vitamin B_1 (thaimine), lutein and vitamin C. Because of their vitamin C content it is advisable to preserve them uncooked, which can be done as follows: Remove the stalks and wash the berries well. Then, mash them with a wooden pestle to make a puree. Mix the puree thoroughly with honey (weight for weight). Store in jars sealed with paraffin wax and keep in a cool dark place. The mixture will keep better if the jars are sterilized and sealed with metal lids.

(j) Cranberry and Apple Jam with Honey

Cranberries	— 1 kg
Apple	— 3 kg
Honey	— 3 kg
Walnuts	— 1 cup

Sort and wash the cranberries, then boil them in a covered saucepan with half a cup of water until soft. Mash the stewed berries and rub through a sieve. Boil up the honey in an enamel pan, add the apple (peeled, cored and sliced) and walnuts and simmer for an hr. When ready, bottle as for any jam.

2.17 Selected fruits, vegetables and their uses

A brief description of selected fruits and vegetables, which were used in the present study for development of honey based food products is given below:

2.17.1 Aonla

Introduction: The aonla (*Emblica officinalis syn. phyllanthus emblica*), an important minor fruit and a crop of commercial significance, is quite hardy, prolific bearer and highly remunerative even without much care. It belongs to the family Euphorbiaceae and is known as amla, amlaki, amali, ambala, amalakamu and nelli in different parts of India.

Aonla is said to be indigenous to tropical south-eastern Asia, particularly in central and southern India (Firminger, 1947). It is also reported to be the native of India, Sri Lanka, Malaysia and China. It thrives well throughout tropical India and is more popular in India and is commercially cultivated in Uttar Pradesh (Bajpai, 1963; Ram, 1983).

Composition: The fruit is highly nutritive (Table 2.10) and it is the richest source of vitamin C among fruits except Barbados cherry (Asenjo, 1953). The ascorbic acid and

other constituents are well retained in dried aonla fruits (Srivastava and Srivastava, 1964). An easy way to prepare aonla murabba with high vitamin C content has been reported by Gupta and Bopaiah (1986). The aonla powder is superior to synthetic vitamin C in treating deficiencies. The stability of ascorbic acid and presence of astringency in aonla fruit may be assigned to the presence of polyphenols or leucoanthocynins (Sastry et.al, 1956). Hanif et.al, (1966) noted marked antioxidant effect of Gallic acid present in aonla fruit. A comparative evaluation of different products revealed that dried aonla (flakes) had maximum nutritive value followed by Chayvanprash, aonla preserve (murabba), pickle and brined aonla fruits (Naik and Chundawat, 1993).

Table 2.10: Composition of aonla fruits

Constituents	Value
Moisture	81.20%
Protein	0.50%
Fat(ether extract)	0.10%
Mineral matter	0.70%
Fibre	3.40%
Carbohydrates	14.00%
Calcium	0.05%
Phosphorus	0.02%
Iron	1.20%
Calorific value	59/100g
Vitamin B	30mg/100g
Nicotinic acid	0.2mg/100g
Vitamin C	600mg/100g

Source: Bose et. al, 2002.

Uses: The fruits are made into preserve (murabba), sauce, candy, dried chips, tablets, jellies, pickles, tophies, powder etc. It is valued as an antiscorbutic, diuretic, lexative, alterative (Nadkarni, 1927) and antibiotic (Ray and Majumdar, 1976). One or other parts of the plant could be used in treating chronic dysentery (Chopra et. al, 1958), jaundice, dyspepsia, cough (Burkill, 1935) and in tanning and dyeing industries. The literatures regarding its diverse medicinal, industrial and other applications have been thoroughly reviewed (Anon, 1952, Morton, 1960). The properties and nature of

inhibitors of potato virus in the plant extract (Verma et.al, 1969), pharmacological activities of phyllemblin isolated from fruit pulp (Rao and Siddiqui, 1964), protective effect of fruit extract in myocardial necrosis (Tariq et.al, 1977) and antiviral activity (Singh et.al, 1983) have been reported.

2.17.2: Guava

Introduction: Guava (Psidium guajava), the apple of the tropics, is one of the most common fruits in India. It claims to be the fourth most important fruit in area and production after mango, banana and citrus. Guava is quite hardy, prolific bearer and highly remunerative even without much care. The common guava originated, along with a number of other fruits, in tropical America and seems to have been growing from Mexico to Peru. At present the major guava producing countries are Southern Asian countries, the Hawaiian Islands, Cuba and India. It is believed to be introduced in India at a very early date, as it is mentioned by Bruton who was in India early in the17th century. Guava occupied 131625 ha in India. Though it is successfully grown all over the country, the most important guava-growing states are Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra. Uttar Pradesh is by far the most important guava- producing state of India, and Allahabad has the reputation of growing the best guava in the country as well as in the world.

Composition: Guava is a rich source of ascorbic acid and pectin. The ripe fruit contain moisture, dry matter, ash, crude fat, crude protein and crude fibre. The physico-chemical composition of guava fruits varies widely with cultivars, stage of maturity and season (Das et.al, 1995; Kundu et.al, 1995; Ghosh and Chattopadhyay, 1996). The total soluble solids content in fruit varies from 8.2 to 10.5°brix (Mitra, 1983; Kundu et.al, 1995). The total sugar content ranges between 4.9 and 10.1% (Table-2.11). Fructose (59%), glucose (36%) and sucrose (5%) are the predominant sugars in ripe guava fruits (Chan and Kwok, 1975). Fructose is the principal sugar in green ripe fruits while sucrose is the main one in fully ripe fruits (Arenas de Moreno et.al, 1995). Fruits are fair source of vitamin A (about 250 IU/100g) and contain appreciable quantities of thaimine, niacin and riboflavin.

Table 2.11 Composition of guava fruits

Constituents	Value
Moisture	77.9-86.9 %
Dry matter	12.3-26.3 g/100g
Ash	0.51-1.02 g/100g
Crude fat	0.10-0.70 g/100g
Crude protein	0.82-1.45 g/100g
Crude fibre	2.0-7.2 g/100g
Sugar	
Reducing	2.4-5.2 g/100g
Non-reducing	2.5-3.8 g/100g
Total	4.9-10.1 g/100g
Acidity	0.22-0.39 g/100g
Ascorbic acid	75.2-234.3 mg/100g
Thiamine	0.03-0.07 mg/100g
Riboflavin	0.02-0.04 mg/100g
Niacin	0.20-2.32 mg/100g
Calcium	10.0-30.0 mg/100g
Phosphorus	22.5-40.0 mg/100g
Iron	0.60-1.39 mg/100g

Source: Wilson (1980), Singh (1988), Das et.al, (1995), Ghosh and Chattopadhyay (1996)

Uses: Guava fruit is relished when mature or ripe and freshly plucked from the tree. Excellent salad and pudding are prepared from the shell of the ripe fruit. It can be preserved by canning as halves or quarters, with or without seed core (shells). The cv. Allahabad seedless white guavas have been reported to be more suitable for canning as halves (Siddappa, 1982). The guava jelly is well- known to all with an attractive purplish-red colour, pleasant taste and aroma. The common sour wild guava makes the best jelly. High quality nectar can be prepared from guava (Baramanray et.al, 1995). Puree made from cv. EEA 18-40 was the best in flavour, colour and aroma (Pinera et.al, 1997). Ripe fruits are also used for manufacturing of icecream, sherbet, cheese and toffee. Guava jam and juice concentrate are also liked for their

characteristic taste. Two types of wines, viz. guava juice wine and guava pulp wine are also prepared from guava fruits (Bardiya et.al, 1974).

2.17.3 Papaya

Introduction: Papaya (Carica papaya) also called papaw or pawpaw, is a quick growing, typically single-stemmed, short-lived, large perennial herb. The papaya is an important fruit of tropical and subtropical regions of the world. It is a native of tropical America (Hafmeyr, 1938) and was introduced in India in the 16th century. It is now grown in all the tropical and subtropical countries like Australia, Hawaii, Taiwan, Puerto Rico, Peru and Florida, Texas, California in the USA, Gold Coast, various part of central and South Africa, Pakistan, Bangladesh and India.

Composition: Papaya is a very wholesome fruit. Aykroyed (1951) ranks it second only to mango as a source of the precursor of vitamin A. while this vitamin is generally associated with carotene; the yellow pigment in the papaya is not carotene but caricaxanthin. The ripe fruits contain vitamin A, B, B_1, B_{12}, C and D and also many biologically active tonic substances (Kapanadze and Khasaya, 1988). The composition and food value of ripe papaya fruit are given in Table 2.12.

Table 2.12: Composition and food value of papaya fruit

Constituents	Values
Moisture	89.6 %
Protein	0.5 %
Fat	0.1 %
Carbohydrate	9.5 %
Calcium	0.01 %%
Phosphorus	0.01
Vitamin A	2020 IU/100g
Vitamin B_1	0.04 mg/100g
Vitamin C	40.0 mg/100g
Nicotinic acid	0.2 mg/100g
Riboflavin	0.25 mg/100g
Calorific value	40 kcal/100g

Source: Bose et.al, 2002

Several enzymes have been isolated and purified from papaya fruits, viz. invertase (Lopez et.al, 1988), UDP-glucose phenol-B-D-glucosyltransferase (Keil and Schreier,

1989), Proteinases (Redina et.al, 1993), pectinesterase (Fayyaz et.al, 1994) and cysteine endopeptidase from C. candamarcensis fruits (Moraes et.al, 1994).

Uses: The ripe fresh fruits of papaya are eaten throughout the tropics and subtropics. They are used in preparation of jam, soft drinks, icecream flavouring, and crystallized fruits and in syrup. The seed are also used for their medicinal value. Unripe fruits are commonly used as vegetable for cooking. Ochase (1931) reported that young leaves are eaten in Java as vegetables. Papain, prepared from the dried latex of immature fruits, is a proteolytic enzyme similar in action to pepsin and is used as meat – tenderizing preparation; in manufacture of chewing gum and cosmetic; as drug for digestive ailments; in the tanning industry for bating hides; for degumming natural silk and to give shrink resistance to wool (Purseglove, 1968). The dried and powderd latex had a proteolytic activity slightly higher than that of the fresh latex (Narine singh and Mohammad Meraj, 1988).

2.17.4 Carrot

Introduction: Carrot (*Daucus carota L.)* is a cool season crop. It is grown all over the world in spring, summer and autumn in temperate countries and during winter in tropical and subtropical climate. The world- wide consumption of carrot has increased over the years and it is now one of the most popular vegetable crop. Carrot is one of the most ancient vegetables (Burkill, 1935). According to Mackevic (1929), Afghanistan is the primary centre of origin of carrot. In India, the carrot is said to have been introduced from Persia. Carrots probably were first grown in America in the Salem garden about A.D. 1620 (Shoemaker, 1947).

Composition: Carrot is valued as food mainly because it is a rich source of α- and β-carotene. Analysis of the edible portion of the carrot gives the following values:

Table 2.13: Composition of Carrot (per 100 g of edible portion)

Constituents	Values
Carbohydrate	10.6 g
Protein	0.9 g
Fat	0.2 g
Moisture	86.0 g
Fibre	1.2 g
Energy	48.0 g

Minerals	1.1 g
Iron	2.2 g
Carotene	1890 μg
Thiamine	0.04 mg
Riboflavin	0.02 mg
Niacin	0.5 mg
Vitamin C	3 mg
Folic acid	15μg
Calcium	80 mg
Phosphorus	30 mg

Source: Bose et.al, 1993.

Uses: Carrot roots are used as a vegetable for soups, stews, curries and pies; grated roots are used as salad, tender roots as a pickles. Gajar halwa is a delicious dish. Carrot jam is also popular and the roots in the form of disc and slices can be dehydrated. Carrot juice is a rich source of carotene and is sometime used for colouring butter and other food articles. Carrots are also canned.

Besides its value as a vegetable, carrot is cultivated in some countries, notably in France, for its seed which is the source of an essential oil- the carrot seed oil. The fruits are collected, dried and the seeds are separated. Carrot seeds are aromatic, stimulated and carminative. They are reported to be useful in diseases of the kidney and in dropsy (Chopra, 1933; Kirtikar and Basu, 1935).

Chapter-3

Materials & Methods

Certain honey based fruits and vegetables products like honey aonla murabba, honey carrot candy, honey mixed fruit jam, honey aonla squash and honey toffee were developed by replacing white sugar with honey. Experimental studies were carried out to examine the effects of different packaging materials and storage temperature on various physico-chemical, textural, microbiological and organoleptic characteristic of these honey based food products. Shelf life studies of different developed products were also carried out. This chapter presents the details of material and methods used *in present investigation.*

3.1 Materials (Honey and fruits & vegetables)

Honey and large sized aonla (Varity: Banarsi) were procured from the K.V.K. Aligarh and orchards of the Agricultural Faculty of A.M.U., Aligarh respectively. Carrot, papaya and guava were procured from the local fruits and vegetable's shops. Compositional constituents of honey and fruits and vegetables used in this study were determined before preparation of the honey based food products.

3.2 Equipment and Apparatus

A number of equipments and Apparatus were required to conduct the present study. These included Digital pH meter for pH measurement (Thermo Orion USA), Soxhalate apparatus for fat estimation (Borosil Glass), Laminar flow for microbial studies (Yarco, India), B.O.D. cum humidity chamber (Yorco, India), Autoclave (Pooja Scientific instrument, New Delhi), High Speed Tissue Homogeniser (Yorco, India), Hot Air Oven for moisture content (Tanco, India), Electronic Balance (Anamed, India), Spectrophotometer for optical density (Digital Spectrophotometer Model 310E, India), Atmospheric Packaging Machine (Quick Seal, Sevana, India), and Texture Analyzer for textural properties (THAD Stable Micro system, England) etc in addition to glassware's and electronic balances.

3.3 Methods

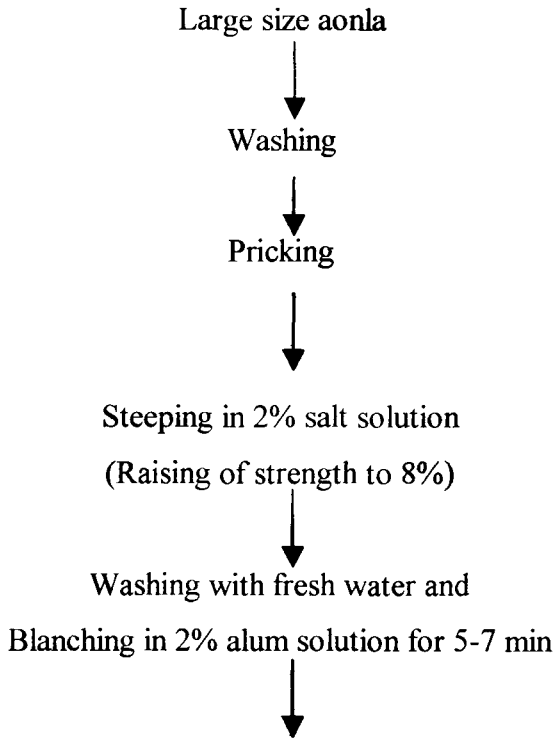
3.3.1 Preparation of Honey based food Products

3.3.1.1 Honey Aonla Murabba: One kg honey was used for the preparation of murabba. The recipe included following:

Aonla fruit	——	1.00 kg
Honey	——	1.00 kg

Water	——	150 ml
Citric acid	——	2- 3 gm

Fruits were washed with cold water and after the damaged ones were discarded, they were properly cleaned and pricked with stainless steel fork/ knife and immersed in two percent NaCl solution at room temperature. Concentration of the solution was increased by two percent/day and the operation was continued for four days. Fruits were taken out form the Nacl solution after four days and washed thoroughly and dipped in fresh water for 1-2 days. The cleaned fruits were blanched in 1-2% potash alum solution for 4-5 minutes or until separation of segments was observed when the fruits were hand-pressed. After the blanching fruits were washed thoroughly to remove the traces of alum. The blanched fruits were transferred in honey syrup of 55-60° Brix and kept in it for one night. Next day fruits were taken out from the syrup and the syrup was boiled .The syrup was cooled and added again with the fruits .The product was kept again for 24 hours. On third day, the process was repeated with addition of the fruits in hot syrup and the product was kept again for two days at ambient temperature. After two days, the fruits and syrup were boiled together till syrup obtained 68-70° Brix corresponding to temperature of 105-106°C. The product was allowed to cool and packed in clean and sterilized dry glass and PET jars, which were stored in cool and dry place. The flow chart for the preparation of honey-aonla murabba is in fig 3.1:



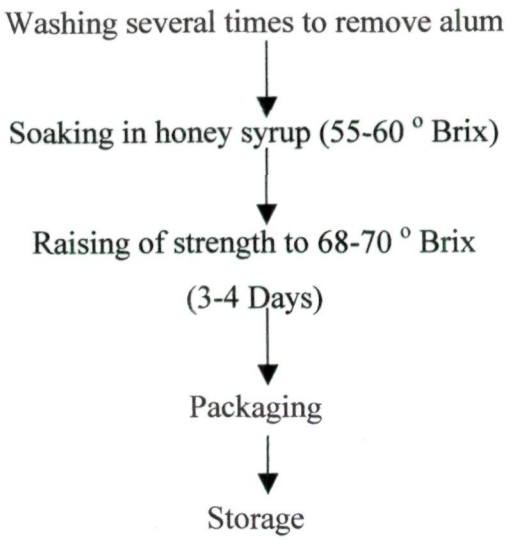


Fig. 3.1 Flow sheet for the preparation of Aonla Murabba in honey syrup

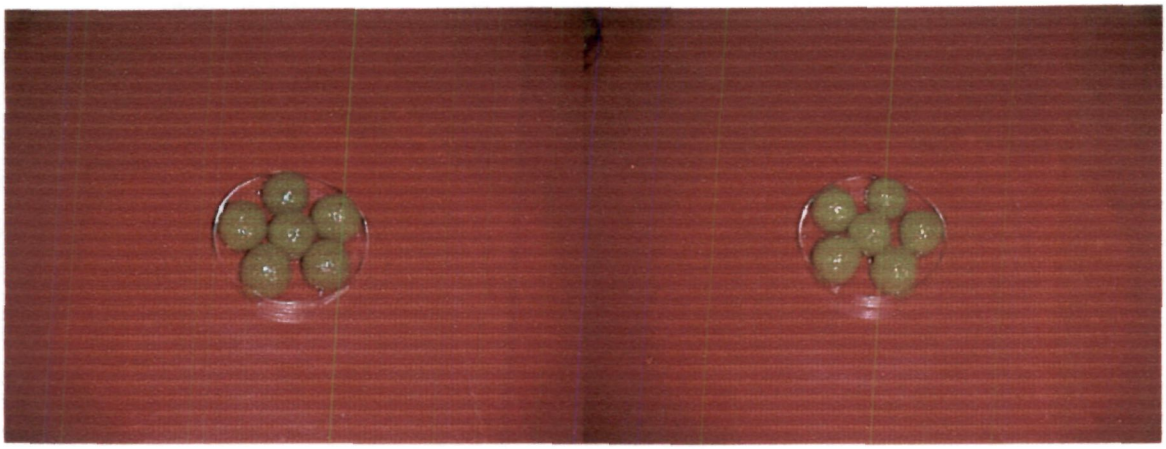


Fig. 3.2 Honey aonla Murabba

3.3.1.2 Honey Carrot Candy: 750 gm of honey was used for the preparation of one kg carrot candy. The recipe included following:

Carrot —— 1.00 kg

Honey —— 750 gm

After washing, peeling and removing inedible portion, the carrots were pricked with stainless steel fork and cut into pieces of 1.25-1.5 cm. lengthwise. The pieces were blanched in boiling water for 5 minutes and blanched pieces were placed on a dry cloth and excess water was allowed to drain off. The pricked and blanched pieces were soaked in honey syrup at room temperature overnight. Next day, the carrots were taken out from the syrup and syrup was boiled. The syrup was cooled and added again with carrots. The product was kept again for 24 hrs. On third day, the process

was repeated with addition of carrots in hot syrup and product was kept again for 24 hrs. Next day, the carrots and syrup were cooked together till the candies obtained 68° Brix. The pieces were dried at room temperature till non-sticky. The prepared candies were packed and stored. A flow chart for the preparation of candies is given in fig 3.3:

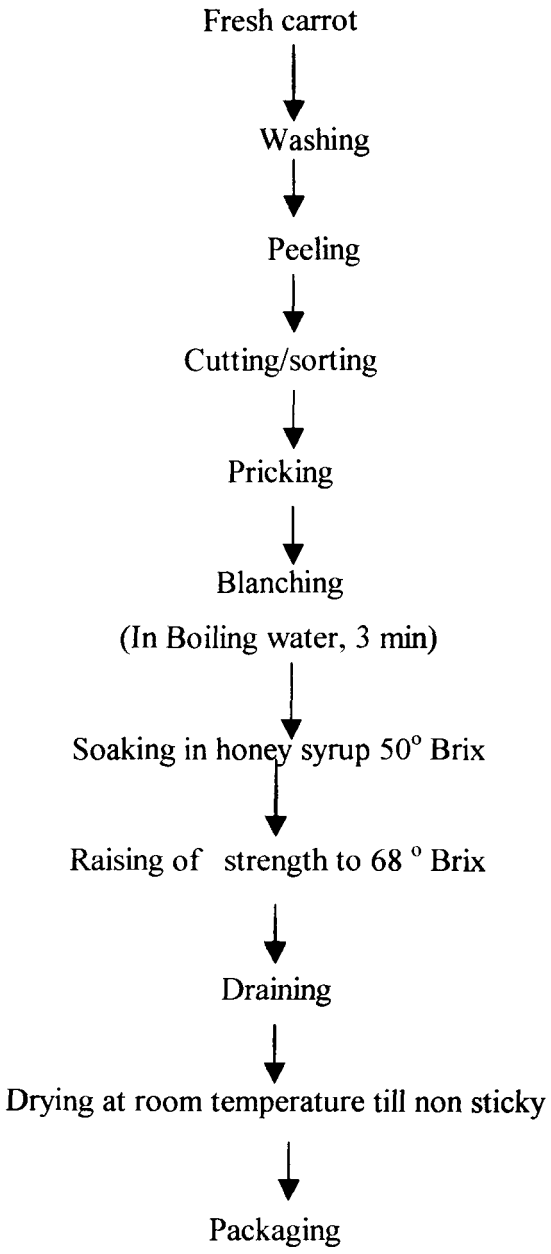


Fig. 3.3 Flow sheet for the preparation of honey carrot candy in honey syrup

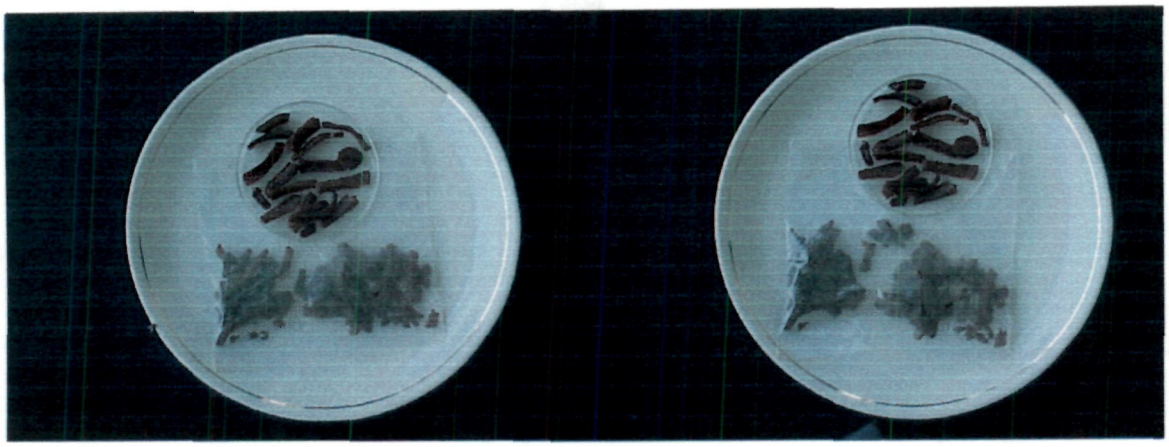


Fig. 3.4 Honey Carrot Candy

3.3.1.3 Honey aonla Squash: 600 ml Aonla fruit juice and 400 ml of honey were used in the preparation of one litre honey aonla squash. The recipe included following:

Aonla fruit juice — 600 ml

Honey — 400 ml

Citric acid — 2 – 3 gm

Kms — 350 ppm

Fruits were washed with cold water and after the damaged ones discarded , they were properly cleaned and heated in boiling water for 15 mins. The seeds were removed and water added in 1:1 ratio. The separated segments were passed through a pulping machine to get pulp. The juice was strained and mixed with honey, citric acid and kms. Now bottling, capping and labeling was done and stored in cool and dry place. The flow chart for the preparation of squash is given in fig 3.5:

Aonla fruit

↓

Washing

↓

Heating in boiling water for 15 minutes

↓

Separation of segments and removal of seed

↓

Addition of water in ratio 1:1

↓

Passing through a pulping machine

↓

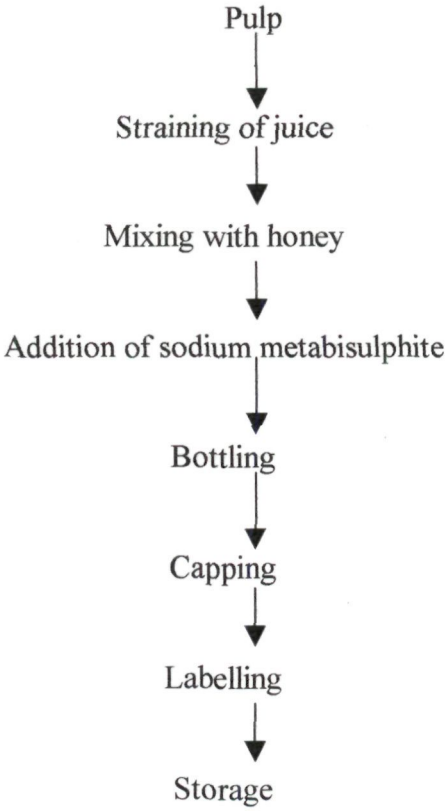


Fig. 3.5 Flow sheet for the preparation of honey aonla squash

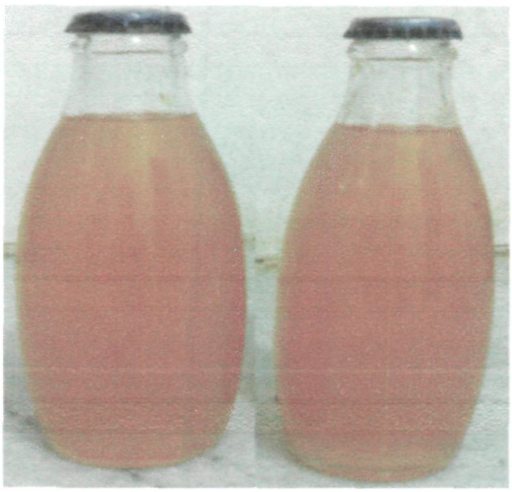


Fig.3.6 Honey aonla Squash

3.3.1.4 Honey Mixed Fruit Jam: 750 gm of honey was used for the preparation of one kg mixed fruit jam. The recipe included following:

Papaya — 500 gm

Guava — 500 gm

Honey — 750 gm

Citric acid — 10.0 gm

Fully matured, sound and uniform sized fruits were cleaned, washed with tap water and manually peeled and cut in to small pieces. The seeds were removed and pieces were passed through mixer to get homogenized pulp. The pulp was concentrated and other ingredients (honey, citric acid) were added. The cooking of pulp was continued till the jam obtained 68.5 ^{o} Brix. Now bottling and cooling of jam in glass bottles was done and stored in room temperature or in refrigerator. The flow chart for the preparation of jam is given in fig 3.7:

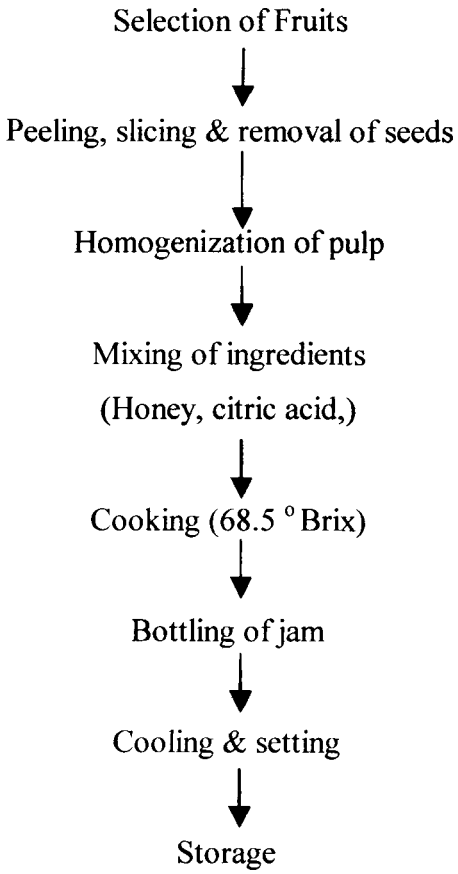


Fig. 3.7 Flow sheet for the preparation of jam

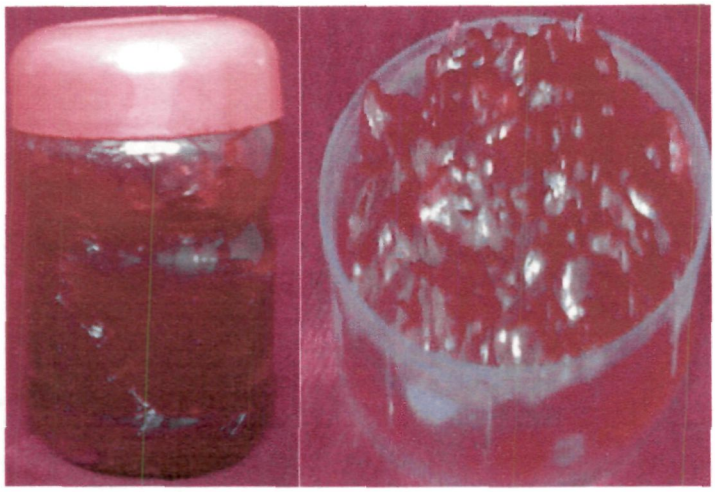


Fig.3.8 Honey mixed fruit jam

3.3.1.5 Honey toffee

Honey (200g) was taken into a boiling pan and heated up to 1 min. then milk powder was added with continuous thorough mixing and heating continued at low flame for 12-15 min. now 24g hydrogenated fat was added and heating was continued for 4-5 min. at low flame. After heating was stopped, the mass thus obtained was spread over stainless steel tray and allowed to cool down for 5 min. The semi solid mass was now fed to the moulding machine for moulding the toffee into the desired shape and size. The toffee thus obtained mass was allowed to dry for 1.5hr. After drying, toffees are individually wrapped in metalized polypropylene sheets manually. These wrapped toffees were then packed in LDPE bag of 500g capacities. The flow chart for the preparation of honey based toffee is given below:

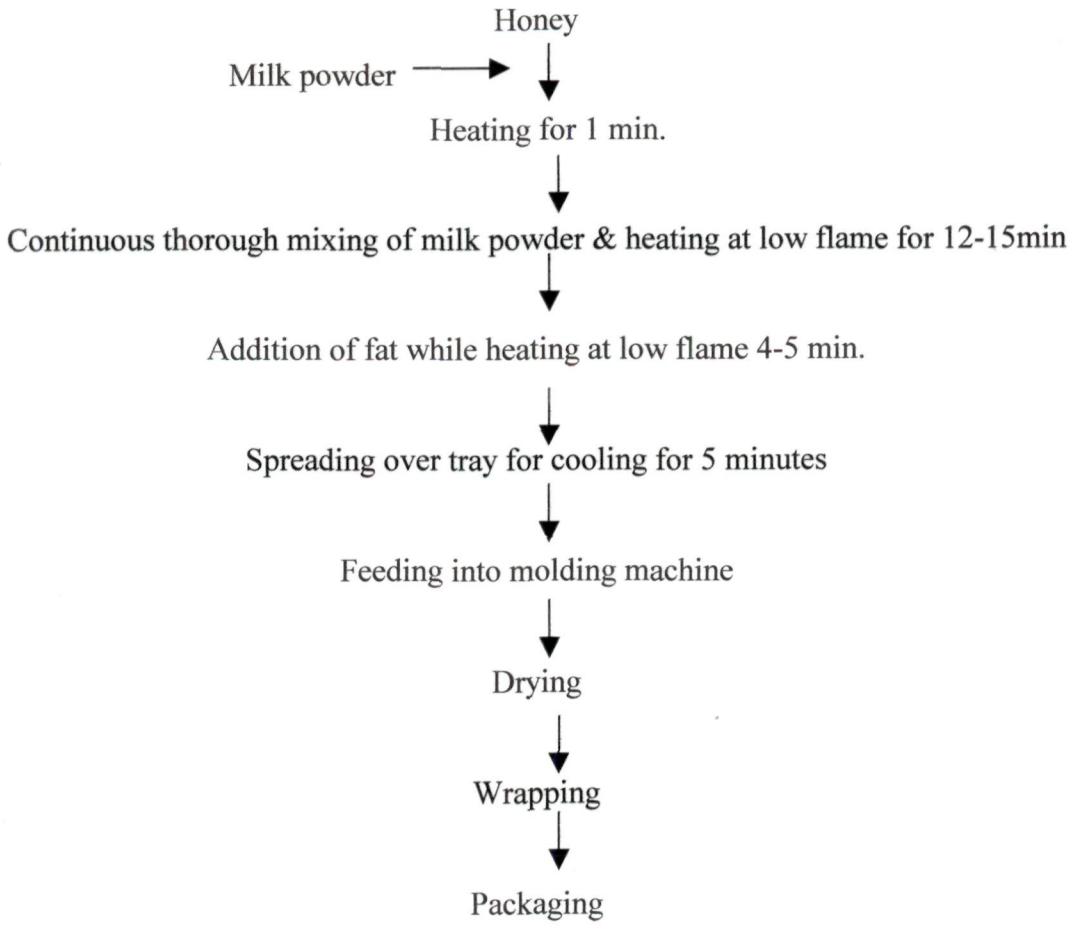


Fig. 3.9 Flow sheet for the preparation of honey toffee

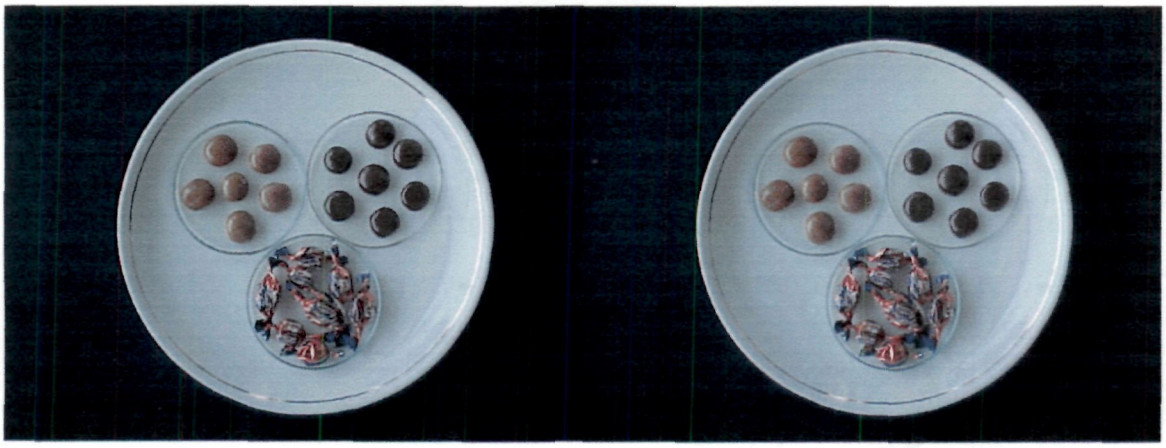


Fig.3.10 Honey and Honey Chicory Toffee

3.3.2.1 Determination of Physico–Chemical Properties Moisture content, pH, browning index, fat content, ascorbic acid content, sugar content, TSS, β-carotene contents, acidity values etc. of fresh products and during storage period were evaluated as per details given below:

(i) Moisture Content

10 g of finely crushed sample was weighed in a flat bottom dried tared dish. The dish and its content were placed in hot air oven which was thermo statistically controlled at 65±5°C and heated until successive weighing showed no further weight loss. At the end, the dish was removed from the oven and placed in a dessicator and allowed to cool and then again weighed. Following formula was used for the estimation of moisture content of honey based food product's sample.

$$\text{Moisture content (\%)} = \frac{\text{Loss in weight}}{\text{Initial weight of sample}} \text{X100}$$

(ii) Total soluble solids (TSS)

Total soluble solid value is defined as the amount of sugar and soluble minerals present in fruits and vegetables. TSS of final products was determined with the help of hand refractometer, which is based on the principle of total refraction. A drop of sample was placed on the prism and the percentage of dry substance in it read directly. Mean value was expressed as percent total soluble solids in °brix.

(iii) Fat Estimation

The soxhlet method suggested by Association of Official analytical Chemist (AOAC) was used for food product's fat extraction as described below:

20g of crushed sample was taken and a thimble was made with the help of porous paper. The thimble was placed in the extracting tube and this tube was connected with the weighed flask and also the condenser.

The heat vaporized the volatile solvent, which passed up the side arm and was condensed in the condenser. The condensed solvent fell drop by drop on to the thimble. When sufficient amount of solvent had thus been transferred to the extracting tube to fill the siphon arm, it siphoned back over in to the weighed flask. This process was continued for 20 hours until the extraction was completed. Then the bottom flask was removed, the volatile solvent was evaporated and fat extracted was obtained as residue. The following formula was used to express fat content of sample.

$$\text{Fat content (\%)} = \frac{\text{Wt of the residue left after evaporation of solvent}}{\text{Wt. of sample taken}} \times 100$$

(vi) pH Measurement

pH is the measurement of the inverse log of hydrogen in the solution. It is expressed as

$$pH = -\log [H]^{+}$$

where, H = Hydrogen ion concentrations (g/lit.)

The electronic pH meter (Digital pH meter, Metzer model) was calibrated using 7 pH and 9 pH standard buffer solutions. Then the electrode was dipped in the test solution and the temperature knob was adjusted to the temperature of test solution. The function selector switch was set to 'pH' and reading of digital display was allowed to stabilize before it was noted.

(v) Determination of Browning Index

Browning index of honey based food products was determined in terms of optical density (O.D.) by method recommended by Srivastava and Kumar (1994). A brief description is given below

10 g of sample was taken in a beaker and 10 ml of distilled water and 30 ml of 60% ethyl alcohol was added. It was thoroughly mixed and the sample was filtered using Whatman filter paper and filtrate was collected. The filtrate was taken in cuvette and optical density of filtrate at 440 nm was measured by spectrophotometer using 60% ethyl alcohol as a blank. The recorded value gives the browning index of the sample.

Fig. 3.11 Spectrophotometer

(vi) Estimation of Reducing sugars and Total sugars

Reducing and total sugars of honey based products were determined by using Lane and Eynon method suggested by Ranganna (2002), as described below:

Reagents

1. Fehling's Solution A: 69.28 g of copper sulphate was dissolved in water and made upto 1000 ml.

2. Fehling's Solution B: 346 g of Rochelle salt (potassium sodium tartrate) and 10 g NaOH was dissolved in water and made upto 1000 ml.

3. Methylene Blue Indicator: 1 g of methylene blue was dissolved in 100 ml of water.

4. 45% Neutral Lead Acetate Solution: 225 g of neutral lead acetate was dissolved in water and made upto 500 ml.

5. 22% Potassium Oxalate Solution: 110 g of potassium oxalate was dissolved in water and diluted to 500 ml.

6. Standard Invert Sugar Solution: 9.5 g of sucrose (analytical grade) was added to 100-ml water and 5 ml. of conc. HCl. Allowed to stand for 3 days at 20-25 °C for inversion to take place and then made upto mark of the one litre volumetric flask with distilled water.

25 ml of the standard invert sugar solution pipetted into a 100 ml volumetric flask and about 50 ml water was added and neutralized with 20% NaOH using phenolphthalein as indicator until the solution turned pink. Acidified with 1N HCl by adding it dropwise until one drop cause the pink colour to disappear. Made upto mark with water (1 ml = 2.5 mg of invert sugar).

Standardization of the Fehling's Solution

Equal quantities of Fehling's solution were mixed and 10 ml of mixed solution was pipetted into 250 ml conical flask and 25 to 40 ml of water was added. Standard invert sugar solution was taken in a 50 ml burette and added to the mixed Fehling's solution, almost the whole of the standard invert sugar solution required to effect the reduction of all the copper, so that no more than 1 ml was required later to complete the titration. The flask containing the cold mixture was heated. When the liquid began to boil, 3 drops of methylene blue indicator were added and boiling was continued during titration. The end point was indicated by the discoloration of the indicator. The

volume of sugar solution required for completely reducing 10 ml of Fehling's solution was noted.

$$\text{Factor for Fehling's solution (g of invert sugar)} = \frac{\text{Titration volume X 2.5}}{1000}$$

Preparation of Sample

50g of finely crushed sample was weighed and 400 ml of water was added to it. The solution was neutralized with 1N NaOH using phenolphthalein indicator followed by gentle boiling with occasional stirring. Boiling water was added to maintain the original level. The solution was cooled and transferred to a 500 ml volumetric flask, made upto the mark by distilled water and solution was filtered through a Whatman filter paper. 100 ml aliquot was pipetted into a 500 ml volumetric flask. To this, 2 ml of neutral lead acetate solution and about 200 ml of water was added. It was allowed to stand for 10 min, then excess of lead was precipitated with potassium oxalate solution. It was made upto the mark and filtered.

Procedure for determination of reducing sugars

The incremental method of titration: 10 ml of the mixed Fehling's solution was pipetted into a 250 ml flask and 50 ml water was added to it. Burette was filled with the clarified sugar solution. Sugar solution from burette sufficient to reduce almost completely the fehling's solution used was added. It was mixed and heated to boiling point on hot plate / burner covered with a clean asbestos, filled wire gauze. It was boiled for 15 sec. if the colour remained blue, 2-3 ml of the sugar solution was further added. The solution was boiled for few seconds after each addition until only a faintest perceptible blue colour remained. 3 drops of methylene blue indicator was added to it and the titration was completed by adding the sugar solution drop wise until the indicator was completely discoloured. The volume of the solution used was recorded.

Procedure for determination of total sugars

50 ml of the clarified solution was pipetted into a 250 ml conical flask. 5 ml of citric acid and 50 ml of water were added to it and boiled gently for 10 min to complete the inversion of sucrose, and then it was cooled. It was transferred to a 250 ml volumetric flask and neutralized with 1 N NaOH using phenolphthalein as indicator, and made upto the volume.

An aliquot was taken and the total sugars as invert sugars was determined by the incremental method of titration.

Calculations

$$\% \text{ Reducing Sugars} = \frac{\text{mg of invert sugar X Dilution X 100}}{\text{Titre value X wt. or volume of sample X 100}}$$

$$\% \text{ Total sugars} = \frac{\text{Mg of invert sugar X Dilution X 100}}{\text{Titre value X wt. or volume of sample X 100}}$$

(vii) Acidity

Titrable acidity was determined as described by Ranganna (2002). To prepare the sample, the samples was pulped with the help of a pestle and mortar, 5 g of pulped sample was then boiled in 100 ml of distilled water for one hour, replacing the water lost by evaporation. It was then cooled, filtered and transferred to a volumetric flask and made upto 100 ml with distilled water. 10 ml of aliquot was pipetted out and titrated against 0.1 N NaOH with few drops of phenolphthalein as indicator.

The titre value was noted and percent total acid was calculated as percent anhydrous citric acid using the following formula

$$\% \text{ Total acid} = \frac{\text{Titre X normality of NaOH X Vol. Made up X Eq. Wt. of Citric acid X100}}{\text{Wt. of sample X vol. of aliquot X 1000}}$$

(viii) Estimation of Vitamin C content

The vitamin C content of honey besed products was determined by using 2,6-dichlorophenol-Indophenol Visual Titration Method suggested by the Ranganna (2002).

Reagents

(1) 3% Metaphosphoric acid (HPO_3): The sticks or pallets of Hpo_3 were dissolved in glass distilled water.

(2) Ascorbic acid standard: 100 mg of l-ascorbic acid was weighed and made up to 100 ml with 3% HPO_3. 10 ml of this was taken and diluted to 100ml with 3% HPO_3 (1 ml = 0.1 mg of ascorbic acid).

(3) Dye Solution: 50mg of the sodium salt of indophenol was dissolved in approximately 150ml of hot glass distilled water containing 42mg of sodium bicarbonate. The dye was cooled and diluted with glass distilled water to 200ml.

Procedure

Standardization of dye: 5ml of standard ascorbic acid and 5ml of HPO_3 was taken in a 100ml conical flask. It was titrated with the dye solution to a pink colour. The dye factor was determined, i.e. mg of ascorbic acid per ml of the dye, using the formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titration value}}$$

Preparation of Sample

10gm of sample was taken. It was blended with 3% HPO_3 and made up to 100ml with HPO_3 and filtered the solution with whatman filter paper.

Assay of Extract: 2-10ml aliquot of the HPO_3 extract of the sample was taken and titrated with the standard dye to the pink end point which should persist for at least 15 sec. It was titrated rapidly and made a preliminary determination of the titre. In the next determination, added most of the dye required and it was titrated accurately. The aliquot of the sample taken should be such that the titre should not exceed 3 to 5ml.

Elimination of Interference due to Sulphur dioxide

10ml of the filtrate was taken in a test tube, 1ml of 40% formaldehyde and 0.1ml of HCl were added. It was allowed to stand for 10 minutes and titrated as before.

Calculations:

$$\text{mg of ascorbic acid per 100 g or ml} = \frac{\text{Titre X Dye factor X vol. Made up X 100}}{\text{Aliquot of extract taken for estimation X Wt. or vol. of sample taken for estimation}}$$

(ix) Estimation of β-carotene content

Reagents

1. Acetone
2. Anhydrous sodium sulphate
3. Petroleum ether

Procedure

5 gm of fresh sample was taken and crushed in 10-1 ml acetone, few crystals of anhydrous sodium sulphate were added, with the help of pestle and morter. The supernatant was decanted into a beaker. The process was repeated twice and the combined supernatant was transferred in a separatory funnel. 10-15ml petroleum

ether were added and mixed thoroughly. Separation of two layers was found on standing. The lower layer were discarded and upper layer was collected in a 100 ml volumetric flask, made up to the 100 ml with petroleum ether and optical density was recorded at 452 nm using petroleum ether as a blank.

Calculation:

$$\beta\text{- carotene } (\mu g /100g) = \frac{\text{O.D. X } 13.9 \text{ X} 10^4 \text{ X } 100}{\text{Wt. of sample X } 560 \text{ X } 1000}$$

$$\text{Vitamin A (I.U.)} = \frac{\text{Beta- carotene } (\mu g /100g)}{0.6}$$

3.3.2.2 Microbiological quality

Microbial analysis was done aseptically to determine the total plate count of the samples on Nutrient Agar (NA) for bacterial count, Potato dextrose Agar (PDA) for yeast and mold count and Mac Conkey Agar for coliform count.

Procedure

Preparation of media: The various compositions are as follows

Nutrient Agar Media (NA)

Peptone	– 5 g
Agar-Agar	– 20 g
Beef extract	– 1.5 g
Yeast extract	– 1.5 g
NaCl	– 5 g
Distilled water	– 1000 ml

Potato Dextrose Agar (PDA)

Potato infusion from	– 200 g
Dextrose	– 20 g
Agar	– 15 g
Streptomycin	– 3 mg
Distilled water	– 1000 ml

Mac Conkey Agar

Peptic digest of tissue animal	– 20 g
Lactose	– 10 g
Sodium chloride	– 5 g
Bile salts	– 1.5 g

Neutral red	– 0.05 g
Crystal violet	– 0.001 g
Agar	– 15 g
Distilled water	– 1000 ml

Normal Saline Solution (NSS)

Distilled water	– 1000 ml
NaCl	– 8.6 g

Sterilization

All the necessary glass wares and media such as, required number of petridishes, NA media for TPC, PDA and Mac Conkey Agar media for yeast and mold count and for coliform count respectively, 9 ml of NSS distributed in 7 test tubes for TPC and 7 test tubes for yeast and mold count and 7 test tubes for coliform count, microbial tips (1ml, 0.5ml), spreader were heated for 20 min. in an autoclave maintained at 15 psi for sterilization. The autoclave was then switched off and the steam was allowed to escape.

Pouring

This is the transfer of media into petridishes. This was done in the laminar flow chamber. The flame was lighted and petridishes were slightly opened near the flame and the media was poured in the petridishes. The petridishes with media then kept undisturbed for solidification.

Preparation of sample (Serial dilution)

1g of sample was transferred to the test tubes with 9 ml of NSS. It was marked as 10^{-1} and others as 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6}. The test tube containing sample was homogenized with the help of cyclomixer. 1 ml of sample suspended in saline solution from 10^{-1} test tube was transferred in test tube marked as 10^{-2} with the help of micropipette and homogenized. 1 ml of sample from 10^{-2} marked tube was transferred to 10^{-3} with a sterilized 1 ml micropipette. Similarly the sample was transferred till the test tube marked as 10^{-6}. Same procedure was followed for the yeast and mold count and coliform count.

Inoculation of sample

This was also done aseptically in the laminar flow chamber 0.5 ml of the sample suspended a saline solution from 10^{-1} was taken with micropipette and transferred to Petri dish marked as 10^{-1} of NA media. The microbial tip was discarded and another sterilized tip was used to transfer sample from 10^{-2} saline solution to 10^{-2}

NA plates. Precautions were taken in inoculation that contamination should not take place. Similarly all the samples suspended in saline solution were transferred to the respective petridishes of NA media. For each dilution two replicate were taken. A control of NA media was also kept without inoculation. The inoculated petridishes were incubated in a B.O.D. incubator for 48 hours, where the temperature was maintained at 37°C. After 24 and 48 hours, total plate count was taken for NA plates. Same procedure was followed for the yeast and mold count and coliform count.

TPC (cfu/g) = No. of colonies X dilution factor X 10

3.3.2.3 Evaluation of Sensory Characteristics

Sensory attributes such as colour, aroma, texture, taste, juiciness and mouth feel of the honey based products were evaluated as recommended by Ranganna (1994) by Hedonic rating test. A semi - trained panel consisting of 14 judges was selected to evaluate the sample through properly planned experiments. The panelists were selected from the staff and students of Department of Post Harvest Engg. and Technology, Faculty of Agricultural Sciences, AMU, Aligarh.

The requirement for panel membership are (i) good health (ii) average sensitivity (iii) high degree of personnel integrity (iv) intellectual curiosity and interest in sensory evaluation (v) ability to concentrate and learn; and (vi) availability and willingness to spend time in evaluation and submission to periodic test for acuity and consistency. Candidates possessing these qualities are indexed with details of age, sex; specific likes and dislikes etc. Laboratory panels are then carefully trained for specific product. These tests aim at finding differences in specific quality of characteristics between different stimuli and also direction and/or intensity of the differences. Periodically the panel is given refresher training.

Samples were served to the panelists and they were asked to rate the acceptability of the product through the sense of their organs. Different attributes viz. colour, aroma, texture, taste, juiciness and mouth feel of honey based products were rated as scale of the 9 points of the hedonic scale ranging from 1st point (extremely dislike/ most undesirable) to 9th point (extremely like/most desirable) as shown in Table 3.1.

A test proforma was also made and supplied to panelists at the time of evaluation, which is given below

Table 3.1: Performa on 9 Point Hedonic

Attributes	score
Like extremely	9
Like very much	8
Like moderately	7
Likeslightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

3.3.2.4 Instrumental Texture Analysis

Texture profile analysis (TPA Test)

(i) Fracturability

Fracturability is defined as the force required to rupture the material and is measured as the force at the first significant break in the first positive bite area.

(ii) Cohesiveness

Cohesiveness is the property of the material, which determines the extent of deformation. The material withstand file before it ruptures. It is evaluated as the ratio of the positive force area during the second compression cycle to the positive force area during the first compression cycle.

(iii) Hardness

It is defined as the force necessary to attain a given deformation and is evaluated as the peak force during the first compression cycle. The hardness of any biological material is important parameter for its textural evaluation and quality control in terms of maturity, ripeness and storability.

Fracturability = Not all products fracture; but when they do fracture the Fracturability point occurs where the plot has its first significant peak (where the force falls off) during the probe's first compression of the product.

Cohesiveness = PA_2/PA_1 (PA_1 and PA_2 are the areas of first and second bite)

Hardness = h_1 (Peak force) during first compression

Springiness =Height to which the food recovers between end of the first byte and start of the second byte

Gumminess = hardness x Cohesiveness

= $h_1 \times PA_2/PA_1$ (Where h_1 is the hardness)

Stickiness = -ve peak force during first compression

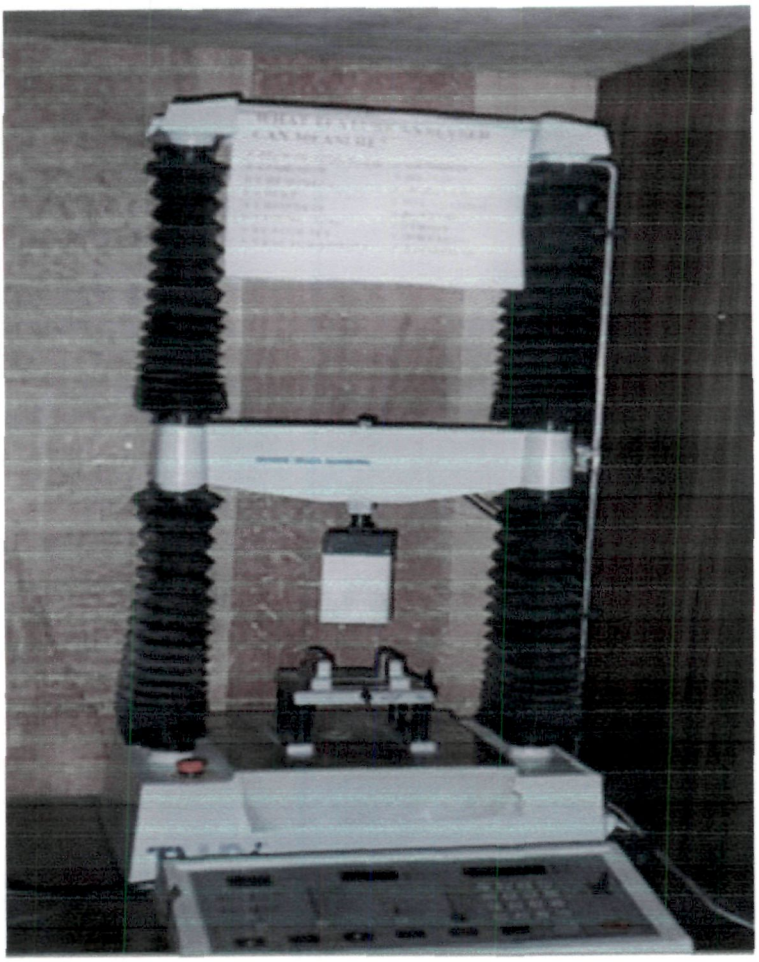


Figure 3.12 TAHD Type texture analyzer

TPA Test Setting:

Texture analysis setting version	**:**	**07.13H**
Load Cell	**:**	**50 kg**
Test Mode and Option		
Measure force in compression		
Repeat until count		
Parameters:		
Pre test speed	**:**	**2.11 mm/s**
Test speed	**:**	**1.00 mm/s**
Post test speed	**:**	**2.00 mm/s**
Rupture test distance	**:**	**4.00%**
Distance	**:**	**50.0 %**
Force	**:**	**100 g**
Time	**:**	**5.00 Sec**
Count	**:**	**2**
Load Cell	**:**	**50 kg**
Temp	**:**	**25^{0}C**
Trigger		
Type	**:**	**Auto**
Force	**:**	**5g**

The probe compression platen (100mm) was used for TPA test and it was performed by two-bite compression. The compression platen (100mm) was attached to the crosshead of Texture Analyzer and the sample was placed on plate form. After making TA setting, the test was run and a graph was created on texture expert. The texture properties were calculated from the graph as follows.

3.3.2.5 Statistical analysis

1. Standard deviation

The best and most commonly used statistical evaluation of the precision of analytical data is the standard deviation. The standard deviation measures the spread of the experimental values and gives a good indication of how close the values are to each other.

Samples were prepared in three replications and data obtained for selected quality parameters were analyzed for mean and standard deviations using following formula:

$$SD = \pm\sqrt{\Sigma(X_i - X)^2 / n}$$

Where,

Xi = individual sample values

X = mean of individual samples

n = total population of sample

2. Analysis of Variance

To test the significance of effect of storage period on quality parameters, analysis of variance (ANOVA) was carried out as applicable to experiments of randomized designs, outlined by Mandal and Nambiar (2002). The critical difference (CD) of mean values were also calculated using formula:

$$CD = \sqrt{\frac{2\,EMSS}{r}} \quad X\,t$$

Where,

EMSS = Errors mean sum of sq.

r = No. of replications

t = Value at 5% and 1% of confidence

3.3.2.6 Economic Feasibility Study

Analysis of economics of manufacturing of honey based food product, taking several assumptions into consideration. Following economic indicators were worked out .

$$\text{(1) Pay back period} = \frac{\text{Total capital investment + Working capital}}{\text{Net annual profit + Depreciation}}$$

$$\text{(2) Return on investment} = \frac{\text{Net annual profit}}{\text{Total capital investment + Working capital}} \times 100$$

(3) Benefit cost ratio = Annual benefit / Total annual cost

(4) Break even point

For x to be brake even point in days

Fixed cost per year + variable cost per day X x = Revenue per day X x

Chapter-4

Results and Discussion

This chapter presents the analysis of data related to use of honey as natural sweetener in place of commonly consumed white sugar used in preparation of various types of food products viz. *candy, murabba, squash, jam and toffees.* White sugar contains high amount of sucrose (99.7%) is an extremely poor food. The excessive consumption of sucrose quite often leads to variety of health problems, which can be avoided by replacing white sugar with natural sweeteners like honey.

The chapter has been subdivided into five sections depending upon the end product. The data relate to optimization of process parameters and various physico-chemical, microbiological, organoleptic and textural characteristics (where ever relevant) of developed products. The changes in these properties of different products during preservation in different packaging materials and stored at different conditions have also been discussed with a view to assess the shelf life of individual products. With a view to encourage small scale processing industries, economics of all individual product manufacturing have also been worked out and presented in this chapter.

4.1 Honey Carrot Candy

Candy is a sweet food prepared form fruits and vegetables by impregnating them with sugar syrup followed by draining of excess syrup and drying of the product to a shelf stable state. Due to high sugar content, the candied products have a longer shelf life.

In past fruits and vegetables like apples, ginger, mangoes, guava, carrots and citrus fruit peels have been used to prepare candies using sugar solution. Karonda, Ber and Aonla candies have also been developed, as reported in Chapter 2 on review of literature.

Keeping in view the large demand of Ash gourd candies, commonly known as 'Petha' and with an idea to develop candies from other fruits viz. mangoes, guavas, carrots etc in honey (in place of sugar), efforts were made to develop honey based candies. Carrot was preferred over other fruits and vegetables because of following reasons:

- Carrot is a highly valued indigenous root vegetable produced abundantly and contains high amounts of nutrients like carrotenoids which are precursors of vitamin A.

- Carrot also contains good amount of dietary fibre having laxative effect.
- Naturally sweet carrots make an ideal high fibre low calorie snack food.
- Cooking increases carrot's nutritive value as it breaks down the tough cellular walls that encase beta-carotene.
- Owing to its seasonal character and perishable nature, a large quantity (about 20-30%) of carrot goes as waste due to inadequate handling and storage practices.
- Though carrot is used widely as salad, vegetable and in development of sweet meats like *Gajar Halwa* and *Gazrila and shredded products,* its use as candies may prove to be a shelf stable delicious addition, enriched with therapeutic advantages of honey, in the list of delicious carrot products.
- Carrot candies developed earlier in sugar and jaggery syrups and using coconut powder for enrobing the candies, even on 60^{th} day of storage at room temperature (when packed in polyethylene bags) scored above 7 on a 9 point hedonic scale with respect to its fresh organoleptic characteristics. The fresh carrot candies prepared respectively in sugar, sugar and coconut powder and jaggery syrups had β - carotene content of 13.29, 13.24 and 11.19 mg/100g which decreased to respectively 11.25, 11.30 and 8.02 mg/100g on 60 days storage (Madan and Dhawan, 2005).

4.1.1 Optimum parameters for carrot candy preparation

For the preparation of carrot candy physiologically mature, firm texture carrots were used. The carrots were blanched in boiling water for 3 minutes after cutting and pricking. The blanched carrot pieces were soaked in honey syrup of varying concentration depending upon admixing of honey with carrot. These treatments using 750g, 1000g and 1250g honey per 1000g carrot (respectively T1, T2 and T3 treatments) were selected for study depending upon trial and error method. The developed syrup was raised to 70^{o}Brix strength from 50^{o}Brix strength and then drained followed by drying of the product at room temperature till candies became non-sticky. The developed products were evaluated for organoleptic properties on a 9 point Hedonic scale by a trained panel. Organoleptic evaluation resulted in the determination of optimized quantity of mix ingredients.

Table 4.1 shows the effect of honey concentration on various organoleptic characteristics of fresh honey carrot candy. The organoleptic evaluation resulted in following observations:

- The average colour score value of candies prepared by treatment T1 was higher (9.00±0) as compared to other two treatments, which scored 8.33±0.57 for both T2, and T3 treatments.
- With respect to flavour, also the candies prepared by treatment T1 scored higher (8.66±0.57) in comparison to samples prepared by treatments T2 and T3 which obtained score of 8.00±0 in both cases.
- Highest score of 8.33±0.57 for taste was also awarded to candies prepared by treatment T1 followed by samples of T2 and T3 treatments in the same order with respective score of 8.00±0 and 7.00±0.
- Similar results for texture of candies were obtained. Samples prepared by T1 treatment obtained highest score of 8.66±0.57 followed by scores of respectively 7.66±0.57 for T2 and 7.00±0 for T3 samples.
- The samples of carrot candies prepared by treatment T1 obtained highest score of 8.66±0.38 with respect to overall acceptability followed by score of 8.00±0.25 for T2 samples and 7.58±0.14 for T3 samples.

Table 4.1: Effect of honey concentration on organoleptic characteristics of honey carrot candies

Codes Allotted	Process Condition	Average Grades for Quality Parameters on 9 Point Scale				
	Honey Concentration during candy preparation	Colour	Flavour	Taste	Texture	O A*
T1	750 gm honey + 1000 gm carrot	9.00±0	8.66±0.57	8.33±0.57	8.66±0.57	8.66±0.38
T2	1000 gm honey + 1000 gm carrot	8.33±0.57	8.00±0	8.00±0	7.66±0.57	8.00±0.25
T3	1250 gm honey + 1000 gm carrot	8.33±0.57	8.00±0	7.00±0	7.00±0	7.58±0.14

* O A. Overall acceptability

Thus with respect to all organoleptic characteristics of developed honey-carrot candies, the samples prepared by treatment T1 which used 750g honey with 1000g carrot were the most preferred candies. In light of these observations, further

studies were conducted with T1 treatment only which comprised of studies of other relevant characteristics of fresh and preserved candies prepared by admixing 750g honey with 1000g carrot.

4.1.2 Effect of storage period and packaging material on Physico – chemical characteristics

Table 4.2 presents the various physico-chemical characteristics of honey carrot candies developed in present study in both fresh conditions as well as during 180 days storage at ambient conditions after packaging in glass jar and LDPE pouches. Characteristic wise results are discussed below:

Table 4.2: Effect of storage period and packaging material on physico-chemical constituents of Honey carrot candy during storage at room temperature

Parameters	Storage period (Days)/ packaging material						
	0	30		90		180	
		Glass Jar	LDPE Pouch	Glass Jar	LDPE Pouch	Glass Jar	LDPE Pouch
Moisture Content,%	28.00±0.50	30.50±0.10	30.80±0.10	32.20±0.10	32.60±0.10	34.00±0.50	34.50±0.50
TSS,°Brix	72.00±0.50	70.50±0.50	70.10±0.28	68.50±0.10	68.00±0.30	66.50±0.15	66.00±0.17
Acidity,%	0.064±0	0.075±0.001	0.079±0.001	0.085±0.001	0.088±0.001	0.12±0.001	0.12±0.0
Browning Index	0.02±0.005	0.03±0.005	0.03±0.005	0.046±0.005	0.053±0.005	0.06±0.01	0.066±0.005
Reducing Sugars,%	30.50±0.19	33.46±0.15	33.83±0.11	36.90±0.10	37.00±0.11	38.70±0.10	39.06±0.11
Total Sugars,%	78.00±0.20	78.50±0.10	78.8±0.10	79.50±0.10	79.80±0.10	81.20±0.17	81.60±0.10
β- carotene, mg/100g	16.27±0.02	14.40±0.17	14.20±0.17	12.03±0.05	12.00±0.05	11.23±0.05	11.06±0.11

4.1.2.1 Effect on Moisture Content

In comparison to average moisture content of 17.2% of honey the fresh honey carrot candy (0^{th} day of storage) had average moisture content value of 28.00 (± 0.5) % which gradually and significantly increased maximum up to 34.00(± 0.5) % in glass jar and 34.50(± 0.0) % in LDPE pouches on 180^{th} day of storage at ambient conditions. Table 4.2 (a) presents the results of ANOVA for this study.

Table 4.2 (a): ANOVA for Moisture content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.67	0.335			
Pack.Sys.(P)	1	0.54	0.54	13.26316	4.6	8.86
Storage(S)	3	108.51	36.17	888.386	3.34	5.56
PXS	3	0.21	0.07	1.719298	3.34	5.56
Error	14	0.57	0.040714			
Total	23	110.5				

CD 5%		CD 1%	
P =	0.176695	P =	0.246879
S =	0.249885	S =	0.34914

The results related to moisture content of honey-carrot candy were compared to following similar products prepared from carrot:

(i) Carrot candy prepared in sugar, sugar and coconut powder and jaggery syrups

Analysis of moisture content of fresh carrot candy prepared in sugar, sugar and coconut powder, jaggery and honey (Table 4.3 to 4.5) syrups (Madan and Dhawan, 2005) showed that these products had moisture content values of 16.20%, 14.20%, 20.98% and 28.0% respectively. The carrot candy prepared in honey syrup had highest moisture content (28.0%) followed by candy in jaggery syrup (20.98%) which increased during storage due to hygroscopic nature of honey and jaggery and also due to permeability of polyethylene (which was used as packaging material) to water vapour as suggested by Madan and Dhawan (2005).

(ii) Intermediate Moisture (IM) carrot preserve

An intermediate moisture (IM) carrot preserve was earlier developed by Division of Horticulture and Fruit Technology, IARI., New Delhi (Sethi and Anand,1982). The moisture content of this prepared IM carrot preserves was 39.2% which increased during storage.

Comparing the results of present study with above described two similar products, developed in different solutions, it may be noted that honey-carrot candy had significantly higher moisture content than jaggery syrup developed carrot candy but little lower moisture content than that of IM preserve. The higher moisture content of honey based carrot candy and increase in its moisture content during storage may be attributed to hygroscopic nature of honey which absorbs moisture from air. Honey has higher hygroscopicity than other sweeteners used in study of Madan and Dhawan (2005). In

present study also, the glass jar had lower permeability to water vapor as compared to LDPE pouches because of which the moisture content of glass jar packed honey candy had slightly lower moisture content as compared to samples packed in LDPE pouches.

These data related to moisture content of honey carrot candy confirm the general observation that honey has the capability to retain water (present in carrot) and honey made product viz. cakes remain moist for longer period than those made with other sweetening agents.

4.1.2.2 Effect on Total Soluble Solids

The total soluble solids (TSS) content of honey carrot candy on 0^{th} day (in fresh condition) was 72.0(±0.5) ° Brix which gradually but significantly decreased minimum upto 66.5(±0.15) °Brix in glass jar and upto 66.0(±0.17) °Brix in LDPE pouches on 180^{th} day of storage. Table 4.2 (b) presents the ANOVA for this study. In all cases, the samples packed in LDPE pouches had slightly lower TSS value as compared to samples packed in glass jar (Table 4.2), though packaging material had no significant effect on TSS.

Table 4.2 (b): ANOVA for Total soluble solids

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.503333	0.251667			
Pack.Sys.(P)	1	0.63375	0.63375	6.008465	4.6	8.86
Storage(S)	3	111.4046	37.13486	352.0687	3.34	5.56
PXS	3	0.24125	0.080417	0.762415	3.34	5.56
Error	14	1.476667	0.105476			
Total	23	114.2596				

CD 5%		CD 1%	
P =	0.2844	P =	0.397364
S =	0.402202	S =	0.561957

The TSS might have been influenced by (i) the mass transfer phenomenon during syruping and (ii) the concentration of sugars present in honey, immersion (during syruping) time and temperature which usually have significant effect on solid gain. It may be recalled here that about 95 to 99% of total solids present in honey are sugars.

As reported in the reference of moisture content, the results related to TSS of honey carrot candy were compared with TSS values of IM carrot preserve developed at IARI, New Delhi. The IM carrot preserve had 54°Brix TSS while the soaking solution (Carrot: solution- 1:2, after equilibration) in which IM preserve was prepared had TSS of 54.30°Brix and the fresh blanched carrot had TSS of 7.8°Brix. In this case also, the higher

value of TSS in case of honey carrot candy in comparison to IM carrot preserve may be attributed to the higher sugar content of honey.

4.1.2.3 Effect on Acidity

The acidity of fresh honey carrot candy (Table 4.2) was 0.064% which gradually but significantly increased with increase in storage period and attained maximum value of 0.12% on 180th day of storage. Insignificant effect of packaging material was observed on the acidity during this period (Table 4.2 c).

Table 4.2 (c): ANOVA for Acidity

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	2.5E-07	1.25E-07			
Pack.Sys.(P)	1	3.04E-05	3.04E-05	38.36842	4.6	8.86
Storage(S)	3	0.013694	0.004565	5766.088	3.34	5.56
PXS	3	1.45E-05	4.82E-06	6.087719	3.34	5.56
Error	14	1.11E-05	7.92E-07			
Total	23	0.013751				

CD 5%		CD 1%	
P =	0.000779	P =	0.001089
S =	0.001102	S =	0.00154

When compared to acidity of other similar products, following observations were noted:

(i) The fresh blanched carrot has acidity of 0.072%. The soaking solution used by IARI, New Delhi for IM carrot preserve had this value at 0.35% and the IM preserve had acidity of 0.17%. The acidity of IM preserve decreased with rise in pH of sample during storage. In the present study also the acidity increased with increased in period of storage.

(ii) The acidity of honey carrot candy (0.064%) was much lower than the acidity of carrot candy prepared in sugar syrup (0.70%), in sugar syrup with coconut powder (0.76%) and in jaggery syrup (0.73%) as reported by Madan and Dhawan (2005) (Tables 4.1.3 to 4.1.5). These workers, have, however also reported increase in acidity of carrot candy (prepared in above syrups) with increase in storage period.

The increase in acidity during storage of acidity of honey carrot candy may be attributed to the reduction in moisture content during this period.

4.1.2.4 Effect on Browning Index

The browning index of honey carrot candy (reported as O.D.) was 0.02(± 0.005) on 0th day of storage (fresh sample) and it gradually but significantly (Table

4.2) increased with increase in storage period and reached to a maximum value 0.066% on 180th day. Packaging material had no significant effect on browning index (Table 4.2 d).

Table 4.2 (d): ANOVA for Browning index

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.000408	0.000204			
Pack.Sys.(P)	1	6.67E-05	6.67E-05	3.612903	4.6	8.86
Storage(S)	3	0.004933	0.001644	89.11828	3.34	5.56
PXS	3	6.67E-05	2.22E-05	1.204301	3.34	5.56
Error	14	0.000258	1.85E-05			
Total	23	0.005733				

CD 5%		CD 1%	
P =	0.003762	P =	0.005256
S =	0.00532	S =	0.007433

The increase in browning index may be attributed to non-enzymatic reactions and presence of sugar which support the formation of brown pigments. Exposure to heat during preparation of candy also might have resulted in formation of brown pigments.

When compared with similar study of Madan and Dhawan (2005), it was observed that the honey carrot candy had significantly very low browning index (OD) while carrot candy in sugar, sugar and coconut powder and jaggery syrups had high OD values of 0.27, 0.19 and 0.39 which also significantly increased during storage (Table 4.3 to 4.5). Among these the candy variant with sugar and enrobbed in coconut was found to show minimum browning with an OD value of 0.20 as compared to candy prepared in jaggery which showed maximum browning with a value of 0.45.

The honey content of carrot candy had significant effect on its browning index. It is well known that the colour of honey is significantly affected by the storage temperature and period (Gupta et.al, 1992). Period of storage of honey significantly increases the colour intensity of honey, which could be attributed to the Maillard reaction resulting in the formation of coloured pigments and higher colloid contents.

4.1.2.5 Effect on Reducing Sugar

The reducing sugar in honey carrot candy on 0th day of storage (in fresh condition) was 30.5(±0.19)% and increased gradually but significantly during 180 days of storage (Table 4.2) upto 38.70(±0.1) in glass jar and upto 39.00(±0.11)% in LDPE pouches. In all cases the samples packed in LDPE had higher value of reducing sugar content over corresponding value in case of samples packed in glass jar. These data

showed that the reducing sugar content was significantly affected by both, storage period and packaging material (Table 4.2 e).

Table 4.2 (e): ANOVA for Reducing Sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.036633	0.018317			
Pack.Sys.(P)	1	0.30375	0.30375	15.48804	4.6	8.86
Storage(S)	3	246.1578	82.05259	4183.816	3.34	5.56
PXS	3	0.14125	0.047083	2.400753	3.34	5.56
Error	14	0.274567	0.019612			
Total	23	246.914				

CD 5%		CD 1%	
P =	0.122634	P =	0.171345
S =	0.173431	S =	0.242318

Similar results were reported by Sethi and Anand (1982) in case of carrot preserves and by Madan and Dhawan (2005) in case of carrot candy developed in sugar, sugar and coconut powder and jaggery syrups (Tables 4.3 to 4.5). The increase in reducing sugars may be because of increased inversion of sugar during storage as reported by Rani and Bhatia (1985).

4.1.2.6 Effect on Total Sugars

The total sugar content of honey carrot candy increased from 78.0(±0.2)% on 0^{th} day to 81.6(±0.1)% in samples packed in LDPE and upto 81.2(±0.17)% in samples packed in glass jar during 180 days of storage. The packaging material did not show any significant effect on total sugar content but the length of storage period had significant effect on total sugar content of honey carrot candy (Table 4.2.f).

Table 4.2 (f): ANOVA for Total Sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.055833	0.027917			
Pack.Sys.(P)	1	0.400417	0.400417	18.03485	4.6	8.86
Storage(S)	3	39.10125	13.03375	587.0429	3.34	5.56
PXS	3	0.15125	0.050417	2.270777	3.34	5.56
Error	14	0.310833	0.022202			
Total	23	40.01958				

CD 5%		CD 1%	
P =	0.130482	P =	0.18231
S =	0.18453	S =	0.257826

However, this trend of increase in total sugar content of carrot candy prepared in honey syrup is contrary to results of similar study by Madan and Dhawan (2005, Tables 4.3 to 4.5). In their study, the total sugar content of carrot candy (prepared respectively in sugar, sugar and coconut powder and jaggery syrups) significantly decreased during storage from 75.96g/100g on 0^{th} day to 74.27g/100g on 30^{th} day and further reduced to 69.63g/100g on 60^{th} day. Also it was reported by Madan and Dhawan (2005) that candy prepared with sugar enrobed in coconut powder had highest sugar content (78.17g/100g) whereas candy prepared in jaggery syrup had sugar content of 71.70g/100g followed by least corresponding value of 69.98g/100g in sugar syrup. These observations may be related to overall sweetness of sweetener. As we know, honey sugars are principally glucose and fructose which are simplest CHO molecules are monosaccharide. Sugar, the refined one is mainly sucrose which disaccharide and consists of fructose and glucose. Honey contains a little over 1% sucrose. Fructose is slightly sweeter than sucrose. Moreover, the colloidal content of honey increases with storage period which might have affected the increase in total sugar content of honey carrot candy.

The total sugar in IM carrot candy is reported to be 28.7% which is very much low as compared to honey carrot candy developed in present study.

4.1.2.7 Effect on β-Carotene

The fresh honey carrot candy had a β-carotene of 16.27(±0.02)mg/100g in comparison to corresponding value of 1890μg/100g in fresh carrots and 11.67mg/100 in fresh blanched carrot and 12.18mg/100g in IM carrot preserve (Sethi and Anand, 1982). With increase in storage period the β-carotene content of honey-carrot candy significantly decreased in gradual manner (Table 4.2). Packaging material had insignificant effect on β-carotene content (Table 4.2g). However, β-carotene content

Table 4.2 (g): ANOVA for β-carotene Content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.008633	0.004317			
Pack.Sys.(P)	1	0.050417	0.050417	4.39589	4.6	8.86
Storage(S)	3	95.94112	31.98037	2788.407	3.34	5.56
PXS	3	0.05125	0.017083	1.489516	3.34	5.56
Error	14	0.160567	0.011469			
Total	23	96.21198				

CD 5%		CD 1%	
P =	0.093781	P =	0.131031
S =	0.132627	S =	0.185306

of samples packed in glass jar had slightly higher value as compared to samples packed in LDPE pouches, probably due to the permeability differences in the oxygen and water vapour barriers of the two packaging materials.

The results of present study related to β-carotene content of honey carrot candy are similar to those reported by Madan and Dhawan (2005), Table 4.3 to 4.5.

Table 4.3: Effect of different Treatments on the physico-chemical constituents of the fresh carrot candy

Candy Variants	Parameters					
	Moisture (%)	Acidity (%)	Reducing Sugars (%)	Total Sugars (%)	β - Carotene (mg/100g)	Browning Index
Candy in sugar	16.20	0.70	43.63	71.14	13.29	0.27
Candy in sugar+ coconut powder	14.20	0.76	47.66	79.39	13.24	0.19
Candy in jaggery	20.98	0.73	43.76	77.34	11.19	0.39
Candy in honey	28.00	0.064	30.50	78.00	16.27	0.02

Table 4.4: Effect of different Treatments on the physico-chemical constituents of the carrot candy after 30 days of storage

Candy Variants	Parameters					
	Moisture (%)	Acidity (%)	Reducing Sugars (%)	Total Sugars (%)	B - Carotene (mg/100g)	Browning Index
Candy in sugar	16.63	0.71	45.10	69.99	12.28	0.35
Candy in sugar+ coconut powder	14.90	0.77	48.92	78.25	12.27	0.19
Candy in jaggery	21.05	0.77	45.30	74.56	9.69	0.41
Candy in honey Glass jar	30.50	0.075	33.46	77.06	14.40	0.03
Candy in honey LDPE pouch	30.80	0.079	33.83	77.36	14.20	0.03

Table 4.5: Effect of different Treatments on the physico-chemical constituents of the carrot candy after 60 & 90 day of storage

Candy Variants	Parameters					
	Moisture (%)	Acidity (%)	Reducing Sugars (%)	Total Sugars (%)	B - Carotene (mg/100g)	Browning Index
Candy in sugar*	17.35	0.74	51.93	68.79	11.25	0.44
Candy in sugar* + coconut powder	15.65	0.79	52.90	76.89	11.30	0.23
Candy in jaggery*	21.40	0.82	56.94	63.21	8.02	0.55
Candy in honey Glass jar**	32.20	0.085	36.90	75.43	12.03	0.046
Candy in honey LDPE pouch**	32.60	0.088	37.00	75.90	12.00	0.053

* Candy after 60 days of storage

** Candy after 90 days of storage

Source: Madan and Dhawan (2005)

The decrease in β-carotene content during storage can be attributed to its sensitivity to light and oxygen. Similar findings were earlier reported by Premavalli and Arya (1991) in carrot 'Halwa'.

Honey carrot candy had higher β-carotene content than IM carrot preserve and carrot candy prepared in sugar, sugar and coconut powder and jaggery syrups, as reported earlier. This variation may be due to varital difference only.

4.1.3 Effect of storage period and packaging material on Microbial characteristics

Table 4.6 shows the data related to microbial characteristics of developed honey carrot candy. The fresh candy did not show presence of any microorganism as reflected by TPC, Y & M count and coliform counts. While no coliform count could be detected during 180 days of storage of honey carrot candy when packed in glass jar and LDPE pouches, yeast and mould count to the extent of 4.35 log cfu/g in glass jar and upto 4.37 log cfu/g in LDPE pouches could be observed only after 180 days storage. The TPC was to the extent of 4.76 (maximum in LDPE

pouch) log cfu/g which could be detected during 90 to 180 days of storage. The packaging material did not show any significant effect on microbial characteristics of

Table 4.6: Effect of storage period and packaging material on Microbiological quality of Honey Carrot candy

	Storage period (days)						
Parameters	**0**	**30**		**90**		**180**	
		Glass Jar	**LDPE Pouch**	**Glass Jar**	**LDPE Pouch**	**Glass Jar**	**LDPE Pouch**
TPC (log cfu/g)	ND	TFTC**	TFTC	4.04±0.01	4.14±0.01	4.69±0.01	4.76±0.05
Y&M count (log cfu/g)	ND	TFTC	TFTC	TFTC	TFTC	4.35±0.05	4.37±0.05
Coliform count (log cfu/g)	ND	ND	ND	ND	ND	ND	ND

* ND – Not Detected

** TFTC – Too few to count

Table 4.6 (a): ANOVA for TPC

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0019	0.00095			
Pack.Sys.(P)	1	0.01215	0.01215	31.306748	4.6	8.86
Storage(S)	3	117.89193	39.297311	101256.88	3.34	5.56
PXS	3	0.0129833	0.0043278	11.151329	3.34	5.56
Error	14	0.0054333	0.0003881			
Total	23	117.9244				

CD 5% **CD 1%**

P = 0.0172513 P = 0.0241035

S = 0.024397 S = 0.0340875

Table 4.6 (b): ANOVA for Y & M Count

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0029083	0.0014542			
Pack.Sys.(P)	1	0.0002042	0.0002042	0.3263559	4.6	8.86
Storage(S)	3	85.608613	28.536204	45614.484	3.34	5.56
PXS	3	0.0006125	0.0002042	0.3263559	3.34	5.56
Error	14	0.0087583	0.0006256			
Total	23	85.621096				

CD 5% **CD 1%**

P = 0.0219027 P = 0.0306026

S = 0.0309751 S = 0.0432786

the product (Table 4.6 a to 4.6 b). However, these counts were in safe limit for human consumption. The reasons for low presence of microbes on honey carrot candy can be attributed to antimicrobial effect of honey due to factor called inhibine (Dold et.al, 1937). The inhibine effect is caused due to hydrogen peroxide produced and accumulated by the action of enzyme glucose oxidase on glucose (White and Subers, 1963). It is reported that honey has bactericidal, bacteriostatic and antifungal activities and nature of antimicrobial factors are due to osmotic effect, acidity, hydrogen peroxide, flavonoids, aromatic and acidic substances. Growth of bacterial species such as *E. coli, S. aureus, H. pylori, Salmonella typhimurium, Shigella sps,* etc. are controlled bacteriostatically or by bactericidal activity of honey (Shamala and Jyothi, 1999). It is also reported that honey's high sugar content shows bacterial growth by reducing the amount of water available to them. Honey's acidity also has antibacterial properties.

The increase in TPC and Y & M counts during prolonged storage of honey carrot candy may be due to favorable environmental factors like temperature, Rh, storage conditions and food factors like pH, redox potential, water activity, moisture content and nutrients present as suggested by Garg and Mandokhst (1984). External contamination may also help in increasing the counts during storage. However, these counts were well below the prescribed limits for khoa (ISI-1980), an other widely consumed edible dairy product.

4.1.4 Effect of packaging materials & storage life on organoleptic characteristics

Table 4.7 shows the various organoleptic characteristic and effects of packaging materials and storage life on these characteristics. The characteristic wise results are discussed below:

Table 4.7: Effect of packaging materials & storage life on organoleptic properties of Honey carrot candy

Parameters	0 days	After 90 days Storage		After 180 days Storage	
		Glass jar	LDPE	Glass jar	LDPE
Colour	8.66±0.57	7.66±0.57	7.50±0.50	6.83±0.28	6.83±0.28
Flavour	8.00±0	7.50±0.50	7.16±0.28	6.83±0.28	6.83±0.28

Taste	8.66±0.57	7.83±0.28	7.66±0.57	7.00±0	6.83±0.28
Texture	8.00±1.00	8.00±0	7.66±0.57	6.66±0.57	6.66±0.57
O.A.	8.33±0.52	7.75±0.19	7.50±0	6.83±0.14	6.79±0.19

4.1.4.1 Effect on Colour

The honey carrot candy in fresh condition was awarded average score of 8.66(± 0.57) on 9 point hedonic scale thereby meaning that it was very much liked. However, this score showed a significant decrease (Table 4.7 a) with increase in storage period. After 90 days of storage the colour score decreased to respectively 7.66(±0.57) in glass jar and upto 7.55(±0.50) in LDPE pouch. After 180 days of storage, the colour score further decreased to 6.83(±0.28) in both packaging material. However, at this stage also the candy was rated between 'Liked moderately to liked slightly'.

Table 4.7 (a): ANOVA for Colour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0560333	0.02801667			
Pckg. Sys(P)	1	0.0128	0.0128	1.8777506	4.96	10.04
Storage(S)	2	10.1556	5.0778	744.90954	4.1	7.56
PxS	2	0.0256	0.0128	1.8777506	4.1	7.56
Error	10	0.0681667	0.00681667			
Total	17	10.3182				

CD 5%		**CD 1%**	
P =	0.0867151	P =	0.12333945
S =	0.1062039	S =	0.15105936

The decrease in colour score of honey carrot candy may be due to its high honey content. Darkening in colour of honey is one of the major changes that occurs during storage and is influenced by temperature, moisture content, pH, free amino acids and reactions between amino acids and reducing sugars (Ramsey and Milum, 1933; Lea and Hannan, 1949; Schade et. al, 1998). Gupta et. al, (1992) have also reported that colour of honey is significantly affected by storage temperature and period. Period of storage, irrespective of temperature and treatments, significantly increase the colour intensity of honey which could be attributed to the maillard reaction resulting in the formation of coloured pigments and higher colloidal contents (Wootton et.al, 1976; Paine and Lothrop, 1933; Ghazali and Sin, 1986; Hodge,1953; Petrou, 1971).

The results related to organoleptic evaluation of carrot candy developed in honey syrup and in other syrups viz sugar, sugar and coconut powder and jaggery have been compared as presented in Figs. 4.1 and 4.2.

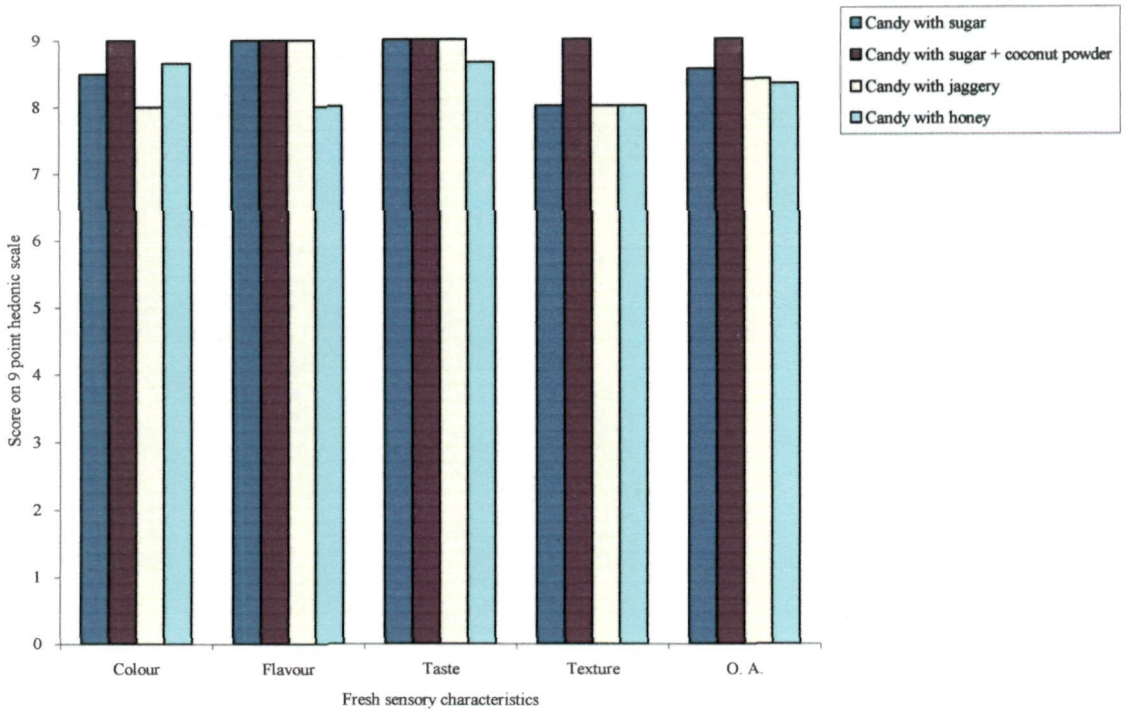
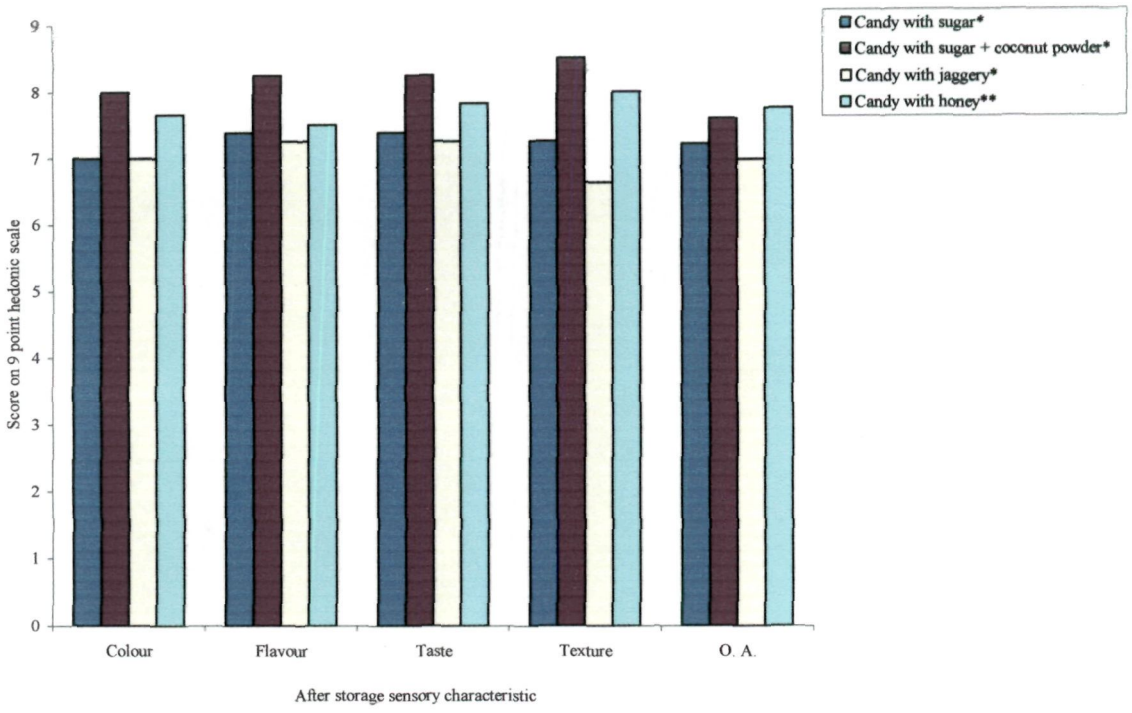


Fig. 4.1 Comparative organoleptic (sensory) characteristic of fresh carrot candies developed with different sweetening agents

It may be noted from these two figures that fresh carrot candy in sugar had a colour score of 8.50 which decreased significantly with increase in storage period and attained the value of 7.00 after 60 days (Madan and Dhawan, 2005). The carrot candy in sugar and coconut powder syrup had a score of 9 on 0^{th} day (fresh) which also decreased significantly to score of 8.00 during 60 days of storage. Similar decrease from score of 8.00 on 0^{th} day to score of 7.00 on 60^{th} day of storage was observed in case of carrot candy developed in jaggery syrup. Comparing these results it may be noted that:

- The honey carrot candy on 0^{th} day had slightly better colour score than carrot candy prepared in sugar or jaggery syrups. However candy developed in sugar syrup with coconut powder only had slightly better colour score than candy developed in honey syrup.



* After 60 days of storage
** After 90 days of storage

Fig. 4.2 Comparative organoleptic characteristics of preserved Carrot candy developed with different sweetening agents

- The candy developed in sugar and jaggery syrups (separately) when stored for 60 days obtained colour score of 7.00 while the candy developed in sugar syrup with coconut powder had a corresponding score of 8.00. in comparison the honey carrot candy which obtained colour score of 7.66(±0.57) in glass jar and of 7.50(±0.50) in LDPE pouches on 90th day. Even after 180 days storage, the colour score of honey carrot candy was 6.83(±0.28) in both packaging material and was rated as between 'liked moderately to liked slightly'.

From above discussions it may be realized that developed carrot candy (in honey syrup) was at par with carrot candy developed in other mediums. The effect of packaging material on colour score was insignificant (Table 4.7 a), though glass jar was slightly better in retaining the colour in comparison to LDPE pouches during first 90 days of storage.

4.1.4.2 Effect on Flavour

From Table 4.7 it may be noted that the honey carrot candy obtained score of 8.00(±0) on 0th day (in fresh condition) showing that it was rated as 'liked very much'. The score, however gradually and significantly (Table 4.7 b) decreased during storage. The flavour scores after 90 days and 180 days storage were respectively 7.50 (±0.50) in glass jar and 7.16(±0.28) in LDPE pouches and 6.83(±0.28) in both glass jar and LDPE pouches.

Table 4.7 (b): ANOVA for Flavour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0126778	0.00633889			
Pckg. Sys(P)	1	0.0589389	0.05893889	13.081381	4.96	10.04
Storage(S)	2	4.1268111	2.06340556	457.96917	4.1	7.56
PxS	2	0.1213444	0.06067222	13.466091	4.1	7.56
Error	10	0.0450556	0.00450556			
Total	17	4.3648278				

CD 5%		CD 1%	
P =	0.070499	P =	0.10027442
S =	0.0863433	S =	0.12281058

These values corresponded to respectively between 'liked very much' to 'liked moderately' and 'liked moderately' to 'liked slightly'. Packaging material did not have any significant effect on flavour of carrot candy, though samples packed in glass jar were rated slightly better than samples packed in LDPE pouches. In similar study Madan and Dhawan (2005), while evaluating the carrot candy developed in sugar, sugar with coconut powder and jaggery syrups had also observed the score of 9.00 on 0th day in all products (rated better than honey carrot candy) which significantly decreased during 60 days storage at ambient conditions (Figs. 4.1 and 4.2). However, from Figs 4.1 and 4.2 it may be noted that samples prepared in sugar syrup with coconut powder were rated better than honey carrot candy on 0th day. Though after 60 days storage only candy developed in sugar syrup with coconut powder proved to be better than honey carrot candy while all other samples were rated at par. Following reasons may be affecting the flavour score of honey carrot candy in comparison to sugar, sugar and coconut and jaggery based carrot candy:

- Processing of honey and its storage temperature affect the flavour of honey (Gupta et. al, 1992).

• Persons do not usually consume honey more than a table spoon and are probably not much attuned to its aroma hence they may not have much liking for it in beginning.

• As the moisture content of honey carrot candy increased during storage as was the case in reducing sugar and total sugar and acidity, the pH of final product having bearing on flavour might have been effected.

4.1.4.3 Effect on Taste

The score for taste of honey carrot candy was 8.66(±0.57) on 0^{th} day (Table 4.7) showing that it was rated as between 'liked extremely to liked very much'. The taste score, however, decreased gradually but significantly (Table 4.7 c) during 90 and 180 days storage. It was rated as very near to 'liked very much' after 90 days and as 'liked moderately' after 180 days. During first 90 days of storage the packaging material influenced the taste score and glass jar was found to have better water vapour properties than samples packed in LDPE pouches but after 180 days both packaging materials had same score.

Table 4.7 (c): ANOVA for Taste

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0127	0.00635			
Pckg. Sys(P)	1	0.05445	0.05445	7.5730181	4.96	10.04
Storage(S)	2	9.1407	4.57035	635.65369	4.1	7.56
PxS	2	0.0273	0.01365	1.8984701	4.1	7.56
Error	10	0.0719	0.00719			
Total	17	9.30705				

CD 5%		CD 1%	
P =	0.0890581	P =	0.12667194
S =	0.1090734	S =	0.15514081

4.1.4.4 Effect on Texture

Texture is related to mouth feel of product. The honey carrot candy obtained score of 8.00(±1.0) on 0^{th} day i.e. in fresh condition thereby meaning that the product was rated as 'liked very much'. With increase in storage period the texture, however decreased, though this decrease was initially not significant during first 90 days storage but during 180 days storage the decrease was significant (Table 4.7 d).

Table 4.7 (d): ANOVA for Texture

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0012111	0.00060556			
Pckg. Sys(P)	1	0.0578	0.0578	11.531811	4.96	10.04
Storage(S)	2	6.3533778	3.17668889	633.78852	4.1	7.56
PxS	2	0.1156	0.0578	11.531811	4.1	7.56
Error	10	0.0501222	0.00501222			
Total	17	6.5781111				

CD 5%		CD 1%	
P=	0.0743574	P=	0.10576236
S=	0.0910688	S=	0.12953191

Comparing the scores awarded to various types of carrot candy (Fig 4.1 and 4.2) it may be noted that honey carrot candy was at par with carrot candy in sugar and jaggery syrup and inferior to candy developed in sugar syrup with coconut powder only even after 60 days of storage.

4.1.4.5 Effect on Overall acceptability

The fresh honey carrot candy had an average overall acceptability score of 8.33 (±0.52) which means that the product was ranked as between 'liked extremely to liked very much (Table 4.7). This score, however, decreased gradually but significantly (Table 4.7 e) with increase in storage period and was not affected by packaging material. The product was slightly inferior to carrot candy developed in sugar syrup with coconut powder (Figs. 4.1 and 4.2) but almost at par with carrot candy in sugar and jaggery syrup (reported separately by Madan and Dhawan, 2005).

Table 4.7 (e): ANOVA for Overall acceptability

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	5.378E-05	2.6889E-05			
Pckg. Sys(P)	1	0.0433161	0.04331606	45.681333	4.96	10.04
Storage(S)	2	6.9721054	3.48605272	3676.409	4.1	7.56
PxS	2	0.0519588	0.02597939	27.397996	4.1	7.56
Error	10	0.0094822	0.00094822			
Total	17	7.0769163				

CD 5%		CD 1%	
P =	0.0323418	P =	0.0460014
S =	0.0396104	S =	0.05633998

Further averaging all the scores for various organoleptic properties of honey carrot candy on 0^{th}, 90^{th} day and 180^{th} day (including samples packed in both packaging materials, as shown in Table 4.7) it may be noted that the fresh candy had a

score of 8.33±0.52 while after respectively 90 and 180 days storage at ambient conditions it had overall mean scores of 7.62±0.43 and 6.8±0.32. In terms of acceptability these corresponded to:

(a) Between 'liked extremely to liked very much' in fresh condition.

(b) Between 'liked very much to liked moderately' after 90 days storage.

(c) Between 'liked extremely to liked very much' after 180 days storage at ambient conditions.

4.1.5. Comparison with other similar products

The honey carrot candy's organoleptic properties have been compared with following products:

(a) Organoleptic properties of IM carrot preserve

(b) Carrot milk cake (khoa/milk based)

(c) Carrot kheer mix

The salient observations are presented below:

(a) Comparison with IM carrot

The IM Carrot preserved in glass bottle and polyethylene for 6 months obtained scores of respectively 7.3 and 7.5 for taste and flavour when tored at low temperature ranging between 1 to 3°C. When stored at room

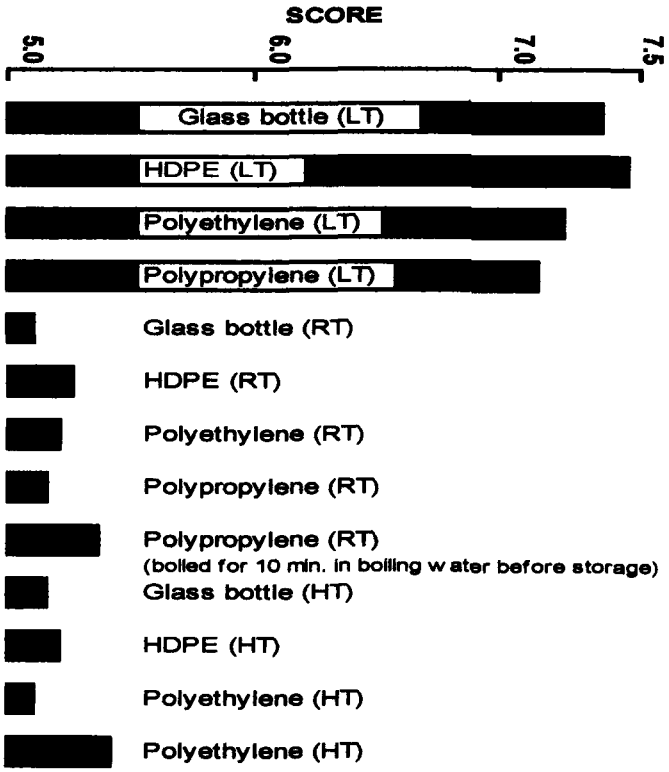


Fig. 4.3 Organoleptic scores of IM carrot after 6 months storage

temperature (25-35°C) the above scores were respectively (approx.) 5.1 and 5.2(fig.4.3).The plastic containers were found to be as good as glass so far the taste and flavour of the product was concerned. Though the product remained microbiologically sound upto 6 months, discolouration of the product was observed even after two months at room temperature (Sethi and Anand, 1982).

In comparison to IM carrot preserve the honey carrot candy scored 6.83 (± 0.28) with respect to taste and flavour when packed in both glass jar and LDPE pouches and stored at room temperature. Thus the honey carrot candy possessed better organoleptic characteristic than IM carrot preserve at room temperature.

(b) Comparison with Carrot milk cake

Gupta et. al, (2005) have reported the organoleptic characteristics of (i) khoa and (ii) milk based carrot cake. The khoa based carrot milk cake had 30% khoa on the basis of carrot shreds while milk based cake had carrot to milk ratio of 1:1.5 (w / v). The organoleptic characteristics of these two types of carrot milk cakes are as reported below (Table. 4.8).

Table 4.8: Comparative organoleptic properties of honey carrot candy and carrot milk cake (9 point scale)

Characteristics	Honey - carrot candy		Carrot milk cake	
	Fresh	After 180 days at room temp.	Khoa based	Milk based
Appearance/colour	8.66±0.57	6.83±0.28	8.50	8.25
Flavour	8.00±0	6.83±0.28	8.83	7.83
Texture	8.00±1.00	6.66±0.57	8.75	8.08
Overall acceptability	8.33±0.52	6.79±0.19	8.69	8.05

In absence of data related to organoleptic characteristics of carrot milk cake only the characteristics related to products are compared. The honey carrot candy had better appearance than both milk and khoa based cake. With respect to flavour, the candy was slightly inferior to khoa based cake but little better than milk based cake. The khoa based milk cake had better score for texture while milk based cake was at par with honey carrot candy. Almost similar trend was observed in case of overall acceptability of all these three products.

Considering the nutritional aspects it was noted that honey carrot candy had 16.27mg/100g β-carotene, 78% total sugars and 30.50% reducing sugar when in fresh

condition while khoa based carrot milk cake had 303.8μg/100g β-carotene, 36.22% total sugars and 7.37% reducing sugars with corresponding values being 280.78μg/100g β-carotene, 35.8% total sugars and 6.85% in case of milk based carrot cake. In comparison to milk and khoa based carrot carrot cake, the honey carrot candy probably had better shelf life at room temperature.

(c) Comparison with Carrot kheer mix

Manjunatha et.al, (2003) had formulated a kheer mix based on dehydrated carrot, skim milk powder, sugar and other ingredients and evaluated for shelf stability as well as sensory quality. The mix could be reconstituted quality as a sweet dish and was found to contain 3.2% moisture, 8.06% fat, 17.70% protein, 15.59% total sugars, 10.17% reducing sugars, 2.5% ash, 23.9 mg % carotenoids. It remained acceptable upto 9 months at 25-30°C and 37°C temperatures in paper-aluminium foil polypropylene laminate pouches.

4.1.6 Effect of storage period and packaging material on Textural Characteristics of Honey Carrot candy

The fresh honey carrot candy in fresh condition had fracturability value of $5.17x10^4$ g.s which increased to $1.92x10^4$ g.s. for samples packed by glass jar after 6 months of storage at ambient temperature. In this case 6 months was the shelf life of honey carrot candy. The fracturability, indicating tenderness of the product decreased significantly to a value of $1.92x10^4$ g.s after 60 days (shelf life) glass jar. The samples packed in pet jar had fracturability of $1.83x10^4$ g.s at 60^{th} day of storage which was the shelf life of such carrot candy. Though the glass jar and pet jar gave the same shelf life of the products, but the overall quality of the honey carrot candy in the glass jar was good and the product was very tender at the stage. The fracturability of honey carrot candy were continuously decreasing during storage period of 60 days.

Hardness of honey carrot candy was decreased with shelf life of storage study. Initially the value of hardness of honey fresh carrot candy was ($2.68x10^4$ g) while 3 months and 6 months of storage it was $1.70\ x10^4$ g and $1.81\ x10^4$ g respectively in glass jar. The value of hardness of honey carrot candy was continuously decreasing up to 6 months of storage but the value of hardness in glass jar was higher as compared to pet jar. After 3 and 6 month of storage in pet jar the hardness value was $1.30\ x10^4$ g and $1.51x10^4$ g respectively. In general there was not much change in hardness of honey carrot candy by the six methods shelf life in glass jar and pet jar (Table 4.9).

Cohesiveness of fresh honey carrot candy was 1.29 which decreased up to 1.34 in glass jar and 1.40 in pet jar. Least changes were observed in case of glass jar as compared to pet jar up to storage period of 6 months. Cohesiveness of the honey carrot candy in glass jar was good as compared to pet jar.

Table 4.9 Effects of storage period and packaging material on textural characteristics of honey carrot candy

No. days/PS	Fracturability, g.s x10^4	Hardness, g x10^4	Cohesiveness
0 days (fresh)	5.17	2.68	1.29
Glass Jar (3 months)	3.98	1.70	1.36
Glass Jar (6 months)	1.92	1.81	1.34
Pet Jar (3 months)	3.34	1.30	1.54
Pet Jar (6 months)	1.83	1.51	1.40

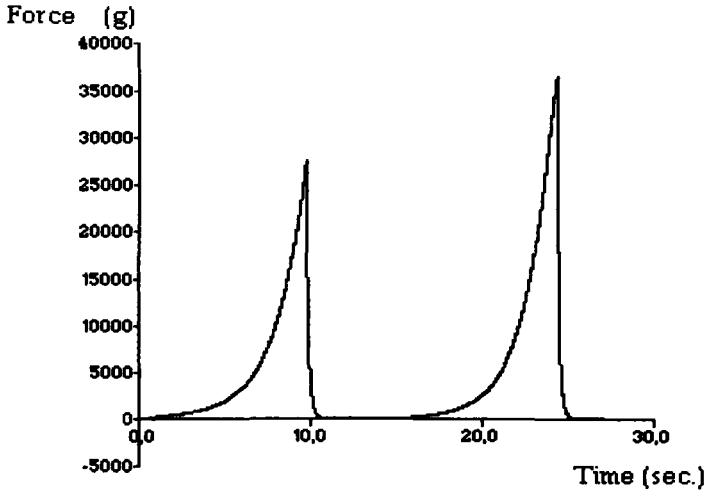


Fig. 4.4 Textural characteristics of fresh honey carrot candy

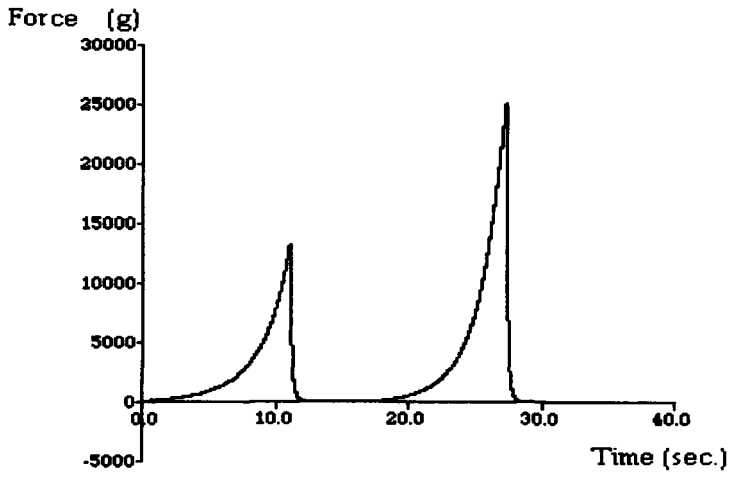


Fig. 4.5 Textural characteristics of 3 months of storage of honey carrot candy in glass jar

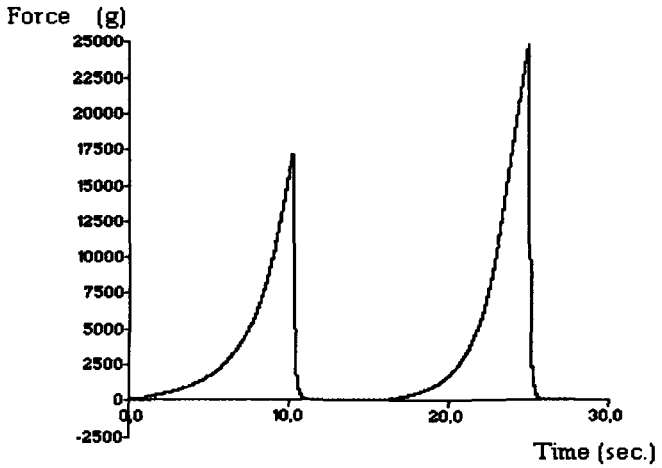


Fig. 4.6 Textural characteristics of 6 months of storage of honey carrot candy in glass jar

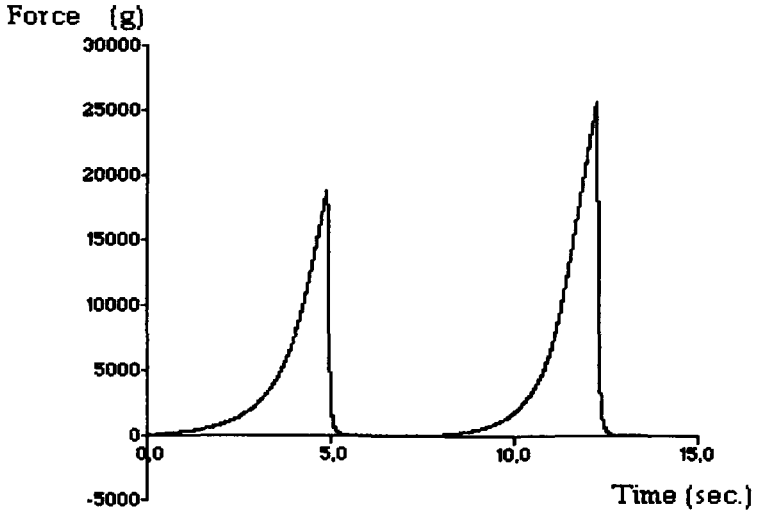


Fig. 4.7 Textural characteristics of 3 months of storage of honey carrot candy in pet jar

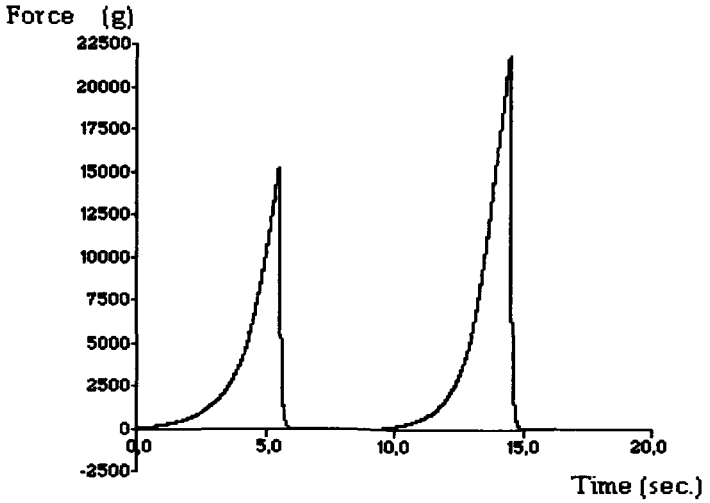


Fig. 4.8 Textural characteristics of 6 months of storage of honey carrot candy in pet jar

4.1.7 Economic Analysis

On the basis of results of study relating to manufacturing of honey carrot candy and its physico-chemical and sensory characteristics, the need of its economic feasibility analysis was felt necessary so that it can be transferred to small scale entrepreneurs. The composition of 1000g carrot in 750g honey was selected keeping in view the composition of candy and its high acceptability even after 180 days sample preservation at ambient temperatures. The results of economic analysis are presented below:

(a) Assumption Following rational assumptions for small scale honey carrot candy manufacturing units were made:

(i) Equipments

- **Supply of potable water**

As the quality of water plays a very important role on the overall quality of final product, a submersible pump for supply of potable water was considered necessary. The estimated cost of submersible pump was Rs. 30,000/- and it would have a life of 10 years with additional Rs. 1000/- for electrical fittings.

- **Utensils**

Simple utensils like Bhagona, Karchi and Sieve will be required for small scale production of honey carrot candy. The cost of which is estimated to be approximately Rs. 5000/-. There utensils may have an estimated life of 10 years.

- **Packaging machine**

A simple hand operated heat sealing machine will be required for atmospheric packaging of produced honey carrot candy. The cost of this machine was considered to be Rs. 3000/- and it is expected to have a life of 10 years with minor repair / maintenance.

A sum of Rs. 1000/- was considered necessary as miscellaneous charges for all these facilities.

(ii) Raw materials

For small scale production, a production target of 10 kg/h was considered. The average cost of raw carrots was considered to Rs. 8/kg and that of honey was considered to be Rs. 75/kg.

(iii) Packaging material

Pouches made of LDPE film have given good results with respect to quality of packaged honey carrot candy, hence it was considered for economic analysis. The cost of pouches was considered to be Rs. 0.15/pouch of 500 g capacity each.

(iv) Space / building

A working shed of 15' X 20' was considered suitable for this cottage industry which was supposed to be hired at a rent of Rs. 1000/month.

(v) Electricity

Electricity used is required for supply of potable water operation of submersible pump and for miscellaneous purposes. The prevailing price of Rs. 3/unit (kWh) was considered and consumption of 2 units (kWh) electricity was required per day.

(b) Other assumption

- **Working days:** Keeping in view the seasonal availability of carrots, a total 100 day /y working days for this small scale carrot candy industry were considered.
- **Annual rate of interest on investment** — Assumed at 15% of capital
- **Cost of repair and maintenance** — Assumed at 5% of initial cost
- **Labour required** — One skilled person @ Rs. 150/day; two unskilled people @ Rs.75/day
- **Cooking fuel** — Ten LPG gas cylinder of 14.5 kg capacity each @400 / cylinder would be required per month.
- **Main product recovery** — 100% product recovery will be obtained

(c) Economic Analysis As the proposed activity is at small scale, working capital requirements have been worked out for 6 days only as shown below:

- **Working Capital requirement, Rs / weak of 6 days**

= Cost of raw materials + Labour charges for 6 days + Rent/ housing for 30 days + Electricity charges for 30 days + Requirement of cooking gas for 6days + Cost of packaging material for 6 days

= Rs. (642.5/h X 8 X 6) + Rs. (300/d X 6) + Rs. 1,000/m + Rs. 180/m + Rs. 960 + Rs. 144

= Rs. (30,840 + 1,800 + 1,000 + 180 + 960 + 144)

= Rs. 34,924/ week

- **Annual Fixed Costs Rs.**

= Depreciation + Interest on fixed capital + Maintenance + Rent/ housing Cost + Interest on working capital for the period of operation

$$= \text{Rs. } \frac{(40{,}000 - 4{,}000)}{10} + \text{Rs. } (.15 \text{ X } 40{,}000) + \text{Rs. } (0.05 \text{ X } 40{,}000) +$$

$$\text{Rs. } (1{,}000 \text{ X } 12) + \text{Rs. } \frac{(0.15 \text{ X } 34{,}924 \text{ X } 100)}{365}$$

= Rs. (3,600 + 6,000 + 2,000 + 12,000 + 1435.23 = Rs. 25035.23

= Say **Rs. 25,036 / —**

- **Capital Investment**

= Initial cost of equipment + 30% of working capital

= Rs. (40,000) + (0.3 X 34,924)

= Rs. (40,000 + 10,477)

= Rs. 50,477 / —

- **Hourly Variable Cost**

= Labour cost + Material cost + Cost of cooking gas + Electricity charges + Maintenance / repair charges + Packaging material cost

= Rs. (300/8) + Rs. 642.50 + Rs. (160/8) +Rs. (6/8) + 0.05 X all Previous charges + Rs. (24/8)

= Rs. (37.5 + 642.50 + 20.0 + 0.75 + (0.05 X 703.75) + 3.0)

= Rs. (703.75 + 35.18) = Rs. 738.93 say **Rs. 739 / hr**

- **Annual Variable Cost**

= Hourly variable cost X No. of operation hrs. / Year

= Rs. 739 X 8 X 100

= Rs. 5, 91, 200 / —

- **Total Annual Cost**

= Annual (fixed + variable) costs

= Rs. (25,036 + 5, 91,200)

= Rs. 6, 16,236 / —

- **Cost of operation, Rs/h**

$$= \frac{\text{Total annual costs}}{\text{Operation hrs. / Year}}$$

$$= \frac{6,\ 16{,}236}{8 \times 100} = \text{Rs. } 770.29 \text{ / hr.}$$

= **say Rs. 771 / hr.**

- **Cost of processing, Rs /kg**

$$= \frac{\text{Hourly cost of processing}}{\text{Capacity per hour}}$$

$$= \frac{\text{Rs. } 771}{15} = \text{Rs. } 51.4 \text{ /kg}$$

= **say Rs. 52 /kg.**

- **Annual Sales Revenue**

= Sale price per kg X Total production per year (kg)

= Rs. 75 X 15 kg /hr. X 8 Hrs. / day X100 Days / year

= Rs. 9, 00, 000 / year

- **Annual Net profit**

= Annual sales revenue – Total annual cost

= Rs. 9, 00,000 – 6, 16, 236

= Rs. 2, 83,764 / —

- **Break Even Point (BEP)**

(a) In terms of no. of operation hrs / year

Let BEP occurs at x hours of operation / year

At this stage, Total costs = total revenues

i.e. Fixed cost + hourly variable cost X x = Per hr. sale revenue X x

Rs. 25,036 + 739 X x = Rs. 75 X 15 X x

Rs. 25,036 + 739x = 1125 x

$$\text{so} \quad x = \frac{25036}{386}$$

= 64.86 hrs. **say 65 hrs.**

(b) In terms of quantity handled

= x X capacity per hr.

= 64.86 X 15 kg / hr

= 972.9 kg/hr **say 973 kg / hr**

- **Pay back period**

$$= \frac{\text{Capital Investment}}{\text{Net profit. Rs/ y + Depreciation}}$$

$$= \frac{50,477}{2,83,764 + 4,000}$$

= **0.17 years**

- **Return on Investment, %**

$$= \frac{\text{Net profit, Rs /y}}{\text{Capital investment}} \times 100$$

$$= \frac{2,83,764}{50,477} \times 100$$

= 562.16 % **say 563 %**

4.2 Honey Aonla Murabba

'*Murabba*' is a fruit preserve. Fruit preserve are usually made from matured fruits and vegetables by cooking them either whole or in large pieces in a concentrated sugar solution till they become tender and transparent (Lal et.al, 1986). Some of the well known fruit preserves are made from *Aonla, apple, bael, ber, cherry* etc while vegetable preserves are commonly made from carrot. This study relates to replacement of sugar syrup with honey for development of '*Aonla Murabba*'.

Amongst various fruits used for preparation of 'Murabba/preserve, *Aonla* was preferred for following reasons:

- *Aonla* or Indian goose berry is an important minor arid zone fruit which is highly nutritive and valued for its vitamin C content and therapeutic properties. It is also rich in tannins.
- Aonla fruits are not consumed in fresh form because of its highly acidic and astringent nature.
- Though Aonla pickles are very much liked and consumed and manufactured at very small scale, development of white specks is a problem which leads to softening and browning of fruit during storage/preservation. These specks give a very bad appearance on the fruit surface and result in heavy economic losses to the producers due to consumer's unacceptability.
- *Aonla* fruits are highly perishable in nature. They can be stored only upto 15 days in cool storage (2-5°C) and upto three months in steeping solution (Jain and Khurdiya, 2002). However, white specks also develop during steeping preservation (Ghorai, 1991). These white specks are identified as a complex of mucic acid (D-galactaric acid) with minerals like calcium and sodium (Premi et.al, 1998).
- Because of restricted availability period (October to January) and highly perishable nature of Aonla fruits due to high moisture content ranging between 81.6 to 85.6% (Singh et.al, 1993), value addition through processing is the only effective way for its economic utilization.
- Amongst various processed and value-added products of '*Aonla*' viz preserves, candy, jam, beverages (RTS, syrup, squash etc.), dried products/shreds, etc preserve or murabba is the most popular. It is reported that Aonla preserve is rich in sugars (65.58%) but poor in protein (0.88%) (Tripathi et.al, 1998). Moreover, prolonged brine treatment of *Aonla* destroys the ascorbic acid content to the extent of 93% (Jain

and Khurdiya, 2002). The preserve contains only 112.28 and 84.60mg/100g ascorbic acid at the start and at the end of storage period of 135 days respectively as against 571.76mg/100g in fresh fruits.

- Darkening and fermentation are the major problems associated with storage of Aonla preserve (Jain and khurdiya, 2002).
- There has not been any major improvement in the manufacturing technology of Aonla preserve during last few decades, except that (i) Ram Chandran et.al, (1996) developed an equipment for preserve making by continuous syrup concentration method, (ii) Mehta and Tomar (1979) recommended use of pectic enzyme for treating blanched fruits, (iii) Nath (1999) reported an easy method for the preparation of preserve which could be adopted at home level, (iv) Singh et.al, (1999) concluded that minimum initial concentration of sugar solution for preparation of Aonla 'murabba'should be 60°B because preserve samples prepared in 40 and 50°B initial sugar concentration got spoiled after 30 days. It was also reported that the process of 'Murabba' preparation should be carried out at or below 40°C in order to minimize non-enzymatic browning and loss of ascorbic acid content of the fruits. The preserve was recommended to be stored at least for 60 days before consumption.
- Bhajekar and kulkarni (1991) isolated osmotolerant yeast; the *saccharooomyces rouxii* from syrup of Aonla preserve that had fermenting smell. The researchers recommended use of a suitable permitted chemical preservative.

Keeping in view, the above mentioned issues in mind and the potential use of honey as natural sweetener as a substitute of white sugar syrup used in preparation of preserve, the present study was carried out to standardize honey based recipe, and to investigate the characteristics of developed product, packaging requirements and shelf life. In this reference various quality attributes of developed honey Aonla Murabba viz physico-chemical, microbial, organoleptic and textural characteristics were evaluated. The results of these investigations are presented and discussed below:

4.2.1 Standardization of recipe and process

The process diagram for preparation of '*Aonla Murabba*' has already been presented through Fig 3.1 in Chapter 3. Accordingly honey concentration was varied between 750g to 1250g per 1000g (1 kg) Aonla fruits. Optimization of ingredients i.e. honey and Aonla fruits was done on the basis of organoleptic scores on 9 point Hedonic scale by a semi-trained panel. Table 4.10 presents the relevant data showing

the effects of honey concentration on organoleptic characteristics of developed preserve in fresh condition. The organoleptic characteristics like colour, flavour, juiciness, texture, taste and overall acceptability were considered as the quality attributes of fresh preserve which decide the products acceptability and palatability.

From the Table 4.10 it may be noted that honey concentration in preserve had significant effect (Tables 4.10 a to 4.10 f) on all above described quality attributes. However, the average scores of all quality attributes for treatment T – 2 which comprised of use of 1000g honey per 1000g Aonla fruit (1:1 ratio) had highest scores for all quality attributes (colour, flavour, juiciness, texture, taste and overall acceptability) in comparison to other two treatments in which respectively 750g and 1250g honey per 1000g fruits were used.

Table 4.10: Effect of Honey concentration on organoleptic characteristics of honey Aonla Murabba

Codes Allotted	Process Condition	Average Grades for Sensory Quality Parameters					
	Honey Concentration during murabba preparation	Colour	Flavour	Juiciness	Texture	Taste	O A*
T1	750 gm honey + 1000 gm aonla	7.05±0.05	7.75±0.05	7.55±0.05	7.55±0.05	6.55±0.05	7.25±0.05
T2	1000 gm honey + 1000 gm aonla	7.85±0.05	8.05±0.05	7.95±0.05	8.05±0.05	8.05±0.05	7.99±0.01
T3	1250 gm honey + 1000 gm aonla	7.15±0.05	8±0	7.85±0.05	7.65±0.05	7.55±0.05	7.64±0.04

O A* Overall Acceptability

Table 4.10 (a): ANOVA for colour

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
replication	1	0.001667	0.001667	0.5		
treatment	2	0.76	0.38	114	6.94	18
error	4	0.013333	0.003333			
total	7					

CD(0.05) = 0.160272
CD(0.01) = 0.265812

Table 4.10 (b): ANOVA for Flavour

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
replication	1	0.006667	0.006667	8		
treatment	2	0.103333	0.051667	62	6.94	18
error	4	0.003333	0.000833			
total	7					

CD(0.05) = 0.080136
CD(0.01) = 0.132906

Table 4.10 (c): ANOVA for taste

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	1	0.001667	0.001667	0.5		
Treatment	2	2.333333	1.166667	350	6.94	18
Error	4	0.013333	0.003333			
Total	7					

CD(0.05) = 0.160272
CD(0.01) = 0.265812

Table 4.10 (d): ANOVA for texture

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
replication	1	0.001667	0.001667	0.5		
treatment	2	0.28	0.14	42	6.94	18
error	4	0.013333	0.003333			
total	7					

CD(0.05) = 0.160272
CD(0.01) = 0.265812

Table 4.10 (e): ANOVA for juiciness

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
replication	1	0.001667	0.001667	0.5		
treatment	2	0.173333	0.086667	26	6.94	18
error	4	0.013333	0.003333			
total	7					

CD(0.05) = 0.160272
CD(0.01) = 0.265812

Table 4.10 (f): ANOVA for O.A.

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
replication	1	0.004267	0.004267	4.129032		
treatment	2	0.548133	0.274067	265.2258	6.94	18
error	4	0.004133	0.001033			
total	7					

CD(0.05) = 0.089236
CD(0.01) = 0.147998

The overall average of all scores (combined) in case of treatments T1, T2, and T3 works out to be respectively 7.27(±0.05), 7.99(±0.37) and 7.64(±0.45). From individual quality attribute point of view, the samples of treatment T2 scores above 8(on 9 point scale) for taste, texture and flavour and almost 8(ranging between 7.85 to 7.99) for other attributes namely colour, juiciness and overall acceptability. The score of 8 corresponded to liked very much. The treatment T2 was considered as the best among all three treatments and the concentration of honey used in this treatment was considered the optimum concentration. Further studies on storage and packaging as well as on other quality attributes were conducted for samples prepared by treatment T-2 only.

4.2.2 Effect of storage period & packaging material on Physico - chemical characteristics

Table 4.11 presents the data related to various-chemical characteristics of fresh as well as preserved honey aonla murabba during 180 days of storage.

Table 4.11: Effect of storage period & packaging material on physico-chemical constituents of Honey Aonla Murabba

	Parameters							
Storage Period (days)	Packaging material	Moisture Content (%)	TSS ^{0} Brix	Acidity (%)	Browning index	Reducing Sugar (%)	Total Sugar (%)	Vitamin C mg /100g
0		48.33±0.29	52.5±0.50	6.88±0.017	0.037±0.00	27.3±0.26	50.4±0.10	152.1 ±0.1
30	Glass Jar	43.81±0.11	56.0±0.0	4.50±0.1	0.041±0.00	28.5±0.10	52.5±0.10	144.1± 0.1
	PET Jar	44.05±0.0	56.0±0.0	4.66±0.01	0.045±0.01	28.8±0.05	52.8±0.1	143.5±0.1
60	Glass Jar	45.50±0.43	55.0±0.0	3.50±0.1	0.05±0.0	29.6±0.1	54.6±0.05	139.8±0.05
	PET Jar	46.70±0.05	54.0±0.0	3.65±0.01	0.05±0.0	30.5±0.01	55.0±0.05	137.2±0.10
90	Glass Jar	46.80±0.05	53.0±0.0	2.64±0.0	0.06±0.0	30.8±0.1	56.2±0.1	132±0.0
	PET Jar	48.30±0.1	52.0±0.0	2.64±0.0	0.06±0.0	31.4±0.1	57.0±0.57	130.4±0.1
120	Glass Jar	48.10±0.1	52.0±0.0	1.83±0.05	0.075±0.0	31.5±0.1	58.2±0.1	127.2±0.2
	PET Jar	49.80±0.1	51.0±0.0	1.86±0.05	0.077±0.0	32.1±0.1	59.0±0.15	125.6±0.1
150	Glass Jar	50.40±0.1	50.0±0.0	1.00±0.0	0.08±0.0	32.2±0.1	59.5±0.1	125.1±0.1
	PET Jar	52.20±0.2	48.0±0.0	1.10±0.1	0.082±0.0	32.8±0.1	60.2±0.05	123.8±0.1
180	Glass Jar	52.20±0.25	48.0±0.0	0.65±0.01	0.095±0.01	33.0±0.05	62.0±0.05	121.5±0.1
	PET Jar	56.5±0.5	44±0	0.64±0.005	0.98±0.51	34.1±0.11	63.1±0.15	119.2±0.05

Individual characteristics wise results of present study are presented and discussed below:

4.2.2.1 Effect on Moisture content

The moisture content of fresh (0^{th} day of storage) honey Aonla Murabba was 48.33(±0.29) % which initially decreased significantly upto 43.81(±0.11) % in glass jar and upto 44.05 % in PET jar during storage of 30 days at room temperature (Table 4.11 a). However, after 30 days of storage, the moisture content of this product started increasing with enhancement of storage period. Maximum moisture content of 52.2(± 0.25)% in glass jar and 56.5(±0.50)% in PET jar was noted on 180^{th} day of storage showing overall increase by respectively 3.87 and 8.2% during entire period of storage.

Table 4.11(a): ANOVA for moisture content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0761333	0.0380667			
Pack.Sys.(P)	1	24.411438	24.411438	431.53208	4.22	7.72
Storage(S)	6	418.98566	69.830943	1234.4333	2.47	3.59
PXS	6	17.239962	2.873327	50.793107	2.47	3.59
Error	26	1.4708	0.0565692			
Total	41	462.18399				

CD 5%	CD 1%
P = 0.1996354	P = 0.269838
S = 0.2823271	S = 0.3816085

The increase in moisture content after 30^{th} day of storage was gradual but significant and in all cases the moisture content values of samples packed in PET jars were significantly higher than corresponding value in glass jar. This is obvious as glass jar has better water barrier properties incomparison to PET jar. Honey being hygroscopic in nature absorbs moisture from air which may the reason for increase in moisture content of preserve during 180 days of storage. However, the initial decrease in moisture content could not be explained.

These results are contrary to the findings in relation to moisture content of Aonla preserve prepared in sugar syrup which was reported to be 65% at 60^{o} Brix and which decreased with increase in period of storage as reported by Singh et.al, (1999) and Tripathi et.al, (1988). Though this aspect needs more detailed studies, the reason for higher moisture content of honey based Murabba may be the higher value of moisture content of honey itself which ranges between 20 to 21% depending upon the

climate. This value of moisture content changes during storage due to hygroscopic nature of honey.

4.2.2.2 Effect on Total soluble solids (TSS)

The fresh (0^{th} day of storage) honey Aonla Murabba had TSS content of 52.5(±0.5)% in comparison to reported value of 20% in case of Aonla preserve developed in sugar syrup (Singh et.al, 1999). In the present study the TSS of honey Aonla preserve initially increased significantly upto 56% (increase by 3.5%) during first 30 days of storage at ambient temperatures (Tables 4.11 and 4.11.b). However, with further increase in storage period, the TSS started showing gradual but significant decrease. The TSS values reached to minimum levels of respectively 48 and 44% when samples were packed in glass jar and PET jars on 180^{th} day of storage at ambient temperatures.

Table 4.11(b): ANOVA for TSS

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.1428571	0.0714286			
Pack.Sys.(P)	1	17.357143	17.357143	526.5	4.22	7.72
Storage(S)	6	404.57143	67.428571	2045.3333	2.47	3.59
PXS	6	17.142857	2.8571429	86.666667	2.47	3.59
Error	26	0.8571429	0.032967			
Total	41	440.07143				

CD 5%		CD 1%	
P =	0.1524009	P =	0.2059932
S =	0.2155274	S =	0.2913184

From above observations it may be noted that during 90 days to 180 days storage at ambient temperature of honey Aonla preserve, the packaging material significantly affected the TSS. However, in all cases, the TSS of preserve was higher in samples packed in glass jar as compared to samples packed in PET jar. Interestingly higher difference in TSS values of honey Aonla preserve packed in these two different types of packaging materials was observed after 150 days of storage at ambient temperature. However, the overall effect of storage was a decrease in TSS content. This finding is again contrary to the findings of Singh et.al, (1999) and Tripathi et.al, (1988). The level of temperature during storage and processing is expected to significantly affect the TSS value. The overall decrease in TSS may be attributed to increase in moisture content of preserve and impregnation of honey into preserve

4.2.2.3 Effect on Acidity

The fresh honey Aonla Murabba had acidity content of 6.88(±0.017) %which gradually but significantly started decreasing with increase in storage period (Table 4.11.c). At the end of 180 days storage at ambient condition, the acidity in samples packed in glass jar and PET jars were reduced to levels of 0.65(±0.01) and 0.64(± 0.005)% respectively. The packaging material, however, did not have any significant effect on acidity of preserve. Singh et.al, (1999) and Tripathi et.al, (1988) have also reported loss of acidity in Aonla preserve during storage. Singh et. al, (1999) had also reported that acidity of Aonla preserve decreased with time at any given concentration and temperature of sugar solution. It was reported by them that the rate constant (a measure of the variation at which a particular constituent varies with time) for acidity increased appreciably when temperature was increased from 30 to 40°C but remained practically unchanged from 40 to 50°C i.e. the rate of loss of acidity increased with temperature reaching to its maximum at 40°C and remained constant.

Table 4.11(c): ANOVA for Acidity

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0094476	0.0047238			
Pack.Sys.(P)	1	0.0414857	0.0414857	16.371206	4.22	7.72
Storage(S)	6	171.97973	28.663288	11311.185	2.47	3.59
PXS	6	0.0474143	0.0079024	3.1184591	2.47	3.59
Error	26	0.0658857	0.0025341			
Total	41	172.14396				

CD 5%		CD %	
P =	0.0422529	P =	0.0571113
S =	0.0597546	S =	0.0807675

4.2.2.4 Effect on Browning Index

The browning index of fresh honey aonla preserve was 0.037 which gradually increased with increase in storage period. The increase in browning index was significant (Table 4.11.d). Maximum value of browning index was 0.095(±0.01) in samples packed in glass jar and 0.098(±0.51) in samples packed in pet jar at the end of 180 days storage. Packaging material, however, had no significant on browning index.

Table 4.11(d): ANOVA for Browning Index

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.037681	0.0188405			
Pack.Sys.(P)	1	0.0788667	0.0788667	4.2114487	4.22	7.72
Storage(S)	6	0.5768813	0.0961469	5.1342053	2.47	3.59
PXS	6	0.4510303	0.0751717	4.0141402	2.47	3.59
Error	26	0.486895	0.0187267			
Total	41	1.6313543				

CD 5%		CD 1%	
P =	0.1148626	P =	0.1552544
S =	0.1624402	S =	0.2195629

4.2.2.5 Effect on Reducing Sugars

The reducing sugar content of fresh (0^{th} day of storage) honey aonla preserve was 27.3(±0.26) % which slowly but significantly increased with increase in period of storage (Table 4.11.e). After 90 days of storage the reducing sugar was 30.8(±0.1) % in samples packed in glass jar and 31.4(±0.1) % in samples packed in PET jar.

Table 4.11(e): ANOVA for Reducing Sugars

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.1319048	0.0659524			
Pack.Sys.(P)	1	3.7202381	3.7202381	262.7749	4.22	7.72
Storage(S)	6	173.82667	28.971111	2046.3424	2.47	3.59
PXS	6	1.1314286	0.1885714	13.319534	2.47	3.59
Error	26	0.3680952	0.0141575			
Total	41	179.17833				

CD 5%		CD 1%	
P =	0.0998713	P =	0.1349915
S =	0.1412394	S =	0.1909068

This corresponded to respective increase in reducing sugars by 3.5% and 2.9% in these two packaging materials. This increase was to the extent of 5.7% in glass jar and 6.7% in PET jar packed samples after 180 days of storage. It was also noted that reducing sugar was always higher in samples packed in PET jar as compared to samples packed in glass jar during entire 180 days period of storage at ambient temperatures. Highest value of reducing sugar was 31.4(±0.1)% in samples packed in PET jar after 180 days.

Singh et.al, (1999) have also reported increase in reducing sugar content of aonla preserve at 60°Brix initial sugar syrup concentration which were preserved for 120 days at temperature ranging between 30 to 50°C. These observations are in agreement with those reported by Tripathi et.al, (1988) also. It is possible that due to onset of the non

enzymatic browning the reducing sugars may have reacted with amino acids and amino groups leading to changes in reducing sugar values.

4.2.2.6 Effect on Total Sugars

The total sugar present in fresh honey aonla preserve (0^{th} day of storage) was 50.4(±0.1)% which also increased significantly during storage period of 180 days at ambient temperature (Table 4.11.f). Maximum value of 62.0(±0.05) % to 63.1(±0.15)% of total sugars was recorded after 180 days of storage. As in case of reducing sugars, the samples packed in PET jar always had higher total sugar in comparison to samples packed in glass jar by significant margin. Thus the packaging material significantly affected the total sugar content

Table 4.11(f): ANOVA for Total Sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0061905	0.0030952			
Pack.Sys.(P)	1	3.6609524	3.6609524	365.42596	4.22	7.72
Storage(S)	6	645.41619	107.56937	10737.271	2.47	3.59
PXS	6	1.352381	0.2253968	22.498477	2.47	3.59
Error	26	0.2604762	0.0100183			
Total	41	650.69619				

CD 5%		CD 1%	
P =	0.0840127	P =	0.113556
S =	0.1188119	S =	0.1605925

These results are in confirmation of results of studies performed by Singh et.al, (1999) and Tripathi et.al, (1988) in case of aonla preserve developed in sugar syrup.

4.2.2.7 Effect on Vitamin C content

The vitamin C content of fresh honey aonla murabba was 152.1(±0.1) mg/100g which started decreasing significantly (Table 4.11.g) with increase in period of storage. Minimum value of 119.26(±0.05)mg/100g for vitamin C was observed in samples packed in PET jar after 180 days of storage at room temperature, though vitamin C content of samples packed in PET jar were slightly lower than corresponding values in glass jar. The effect of packaging material on vitamin C content of preserve was significant after 30 days storage itself. These observations are in confirmation to results of Singh et.al,(1999) and Tripathi et.al, (1988).

Table 4.11(g): ANOVA for Vitamin C content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.037619	0.0188095			
Pack.Sys.(P)	1	10.5	10.5	1067.5978	4.22	7.72
Storage(S)	6	1087.7167	181.28611	18432.443	2.47	3.59
PXS	6	5.1033333	0.8505556	86.481068	2.47	3.59
Error	26	0.2557143	0.0098352			
Total	41	1103.6133				

CD 5% **CD 1%**

P = 0.0832412 P = 0.1125133

S = 0.1177208 S = 0.1591178

4.2.3 Effect of storage period and packaging material on Microbial characteristics

Table 4.12 presents the data related to microbiological characteristics of developed honey aonla murabba. From this Table it may be noted that no microorganisms

Table 4.12: Effect of storage period and packaging material on Microbiological quality of Honey Aonla murabba

Storage period (Days)	parameters			
	Packaging material	TPC (log cfu/g)	Y&M count (log cfu/g)	Coliform count (log cfu/g)
0		ND	ND	ND
30	Glass jar	ND	ND	ND
	PET jar	ND	ND	ND
60	Glass jar	TFTC	TFTC	ND
	PET jar	TFTC	TFTC	ND
90	Glass jar	TFTC	TFTC	ND
	PET jar	TFTC	TFTC	ND
120	Glass jar	2.76±0.11	2.42±0.18	ND
	PET jar	3.71±0.2	3.20±0.07	ND
150	Glass jar	3.57±0.18	3.57±0.11	ND
	PET jar	4.58±0.10	3.94±0.06	ND
180	Glass jar	4.71±0.09	4.76±0.07	ND
	PET jar	4.90±0.04	4.96±0.05	ND

* ND – Not Detected, ** TFTC – Too few to count

were detected in fresh samples. During first 90 days storage of samples packed in glass and PET jars and stored at ambient temperature also the microorganisms were either not detected or were too few to count. After 120 days storage only the presence of microorganisms were noted. The TPC on 120th day of storage was 2.76(±0.11) log cfu/g in glass jar and 3.71(±0.24) log cfu/g in PET jar. This count increased significantly upto maximum 4.71(±0.09) log cfu/g in glass jar and upto 4.90(±0.04) log cfu/g in PET jar on storage of samples for 180 days at ambient temperature. Similarly the Y & M count were respectively 2.42(±0.18) log cfu/g in samples packed in glass jar and 3.20(±0.07) log cfu/g in samples packed in PET jar on 120th day of storage. These counts also significantly increased upto maximum values of 4.76(±0.07) log cfu/g in glass jar and upto 4.96(±0.05) log cfu/g in PET jar on 180th day of storage.

However, in both cases the values of TPC and Y & M counts were within safe limit for human consumption. The glass jar proved better packaging material over PET jar in view of lower microbial counts in samples packed in it. No coliform count could be

Table 4.12(a): ANOVA for Total Plate Count

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0005143	0.0002571			
Pack.Sys.(P)	1	0.3944024	0.3944024	81.286313	4.22	7.72
Storage(S)	6	162.13541	27.022569	5569.3503	2.47	3.59
PXS	6	0.795081	0.1325135	27.311025	2.47	3.59
Error	26	0.1261524	0.004852			
Total	41	163.45156				

CD 5% **CD 1%**

P = 0.0584667 P = 0.0790267

S = 0.0826844 S = 0.1117607

Table 4.12(b): ANOVA for Yeast & mould Count

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0074333	0.0037167			
Pack.Sys.(P)	1	-125.97875	-125.97875	-13227.006	4.22	7.72
Storage(S)	6	175.36101	29.226836	3068.6407	2.47	3.59
PXS	6	128.92632	21.48772	2256.0804	2.47	3.59
Error	26	0.2476333	0.0095244			
Total	41	178.56365				

CD 5% **CD 1%**

P = 0.0819154 P = 0.1107212

S = 0.1158458 S = 0.1565834

detected during 180 days storage. Tables 4.12 (a & b) show the results of ANOVA for microbial characteristics. Honey was responsible for such good antimicrobial characteristic of developed product.

4.2.4 Effect of packaging material and storage period on Organoleptic Characteristics

Table 4.13 shows the effects of packaging materials and storage period on organoleptic characteristics of honey aonla murabba stored at ambient temperature for 180 days. The characteristics wise results are discussed below:

4.2.4.1 Effect on Colour

The fresh samples of honey aonla murabba (on 0^{th} day of storage) obtained score of 8.18 which decreased significantly during storage. The effect of storage period on colour score was significant for samples packed in both packaging materials namely glass jar and PET jars. Similarly packaging materials also significantly effected the colour of the product. The samples packed in glass jar obtained higher score during entire period of study. The samples packed in glass jar were rated as 'liked moderately' while samples packed in PET jar were rated as 'liked slightly' after 180 days of storage (Table 4.13 and 4.13.a).

Table 4.13: Effect of packaging material and storage period on organoleptic characteristic of Honey based Aonla Muraabba

Parameters	Fresh	After 3 Months Storage		After 6 Months Storage	
		Glass jar	Pet jar	Glass jar	Pet jar
Colour	8.18±0.04	7.52±0.04	7.22±0.06	7.15±0.01	6.37±0.05
Flavour	8.14±0.00	7.60±0.03	7.06±0.06	7.10±0.10	6.75±0.04
Juiciness	8.40±0.00	7.82±0.04	7.00±0.00	7.76±0.04	6.58±0.00
Texture	8.38±0.04	7.95±0.05	7.45±0.02	7.52±0.04	6.48±0.08
Taste	7.76±0.04	7.61±0.04	6.86±0.00	6.98±0.01	6.48±0.08
O.A.*	8.15±0.01	7.70±0.01	7.11±0.00	7.31±0.02	6.53±0.03

*OA Overall Acceptability

Table 4.13(a): ANOVA for Colour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	1	0.001045	0.001045			
Pckg. Sys(P)	1	0.396033	0.396033	79.72434	6.61	16.26
Storage(S)	2	4.059056	2.029528	408.5585	5.79	13.27
NxS	2	0.312737	0.156369	31.47811	5.79	13.27
Error	5	0.024838	0.004968			
Total	11	4.79371				

CD 5% **CD 1%**

P = 0.104619 P = 0.16407

S = 0.128132 S = 0.200944

4.2.4.2 Effect on Flavour

In case of flavour characteristics also the effect of storage period was significant. The score of fresh samples for flavour was 8.14 which decreased upto 7.10 in samples packed in glass jar and upto 6.75 in samples packed in PET jar on 180^{th} day of storage (Tables 4.13 and 4.13. b).

Table 4.13(b): ANOVA for Flavour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	1	0.021505	0.021505			
Pckg. Sys(P)	1	0.268203	0.268203	89.696	6.61	16.26
Storage(S)	2	3.062361	1.53118	512.0776	5.79	13.27
PxS	2	0.153902	0.076951	25.73497	5.79	13.27
Error	5	0.014951	0.00299			
Total	11	3.520922				

CD 5% **CD 1%**

P = 0.081168 P = 0.127293

S = 0.099411 S = 0.155902

4.2.4.3 Effect on Juiciness

The fresh honey aonla preserve scored 8.42 on 9 point hedonic scale with respect to its juiciness. The effect of storage period on juiciness score was significant for samples packed in both glass jar and PET jars which declined progressively during storage. The effect of packaging material on juiciness score was also significant.

The score was always higher in case of samples packed in glass jar as compared to samples packed in PET jar. The difference in score of samples in these two packaging materials increased significantly with increase in storage period. At the end of 180 days storage at ambient temperature, the products packed in glass jar scored 7.76 as against score of 6.58 in case of samples packed in PET jar. While the

samples packed in glass jar were rated as between 'liked very much' to 'liked moderately', the samples packed in PET jar were rated as between 'liked moderately' to 'liked slightly' (Tables 4.13 and 4.13.c).

Table 4.13(c): ANOVA for Juiciness

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	1	8.333E-06	8.333E-06			
Pckg. Sys(P)	1	1.0860083	1.0860083	272.29628	6.61	16.26
Storage(S)	2	3.6262167	1.8131083	454.60301	5.79	13.27
NxS	2	0.6133167	0.3066583	76.888842	5.79	13.27
Error	5	0.0199417	0.0039883			
Total	11	5.3454917				

CD 5%		CD 1%	
P =	0.0937426	P =	0.147013
S =	0.1148108	S =	0.1800534

4.2.4.4 Effect on Texture

From the texture point of view, the fresh honey preserve scored 8.38 on a 9 point scale. The effect of storage period on texture score was significant for samples packed in glass as well as PET jars and declined with increase in storage period. In this case also the packaging material had significant effect as samples placed in glass jars scored better than samples packed in PET jars (Table 4.13 and 4.13.d).

Table 4.13(d): ANOVA for Texture

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	1	0.018961	0.018961			
Pckg. Sys(P)	1	0.788994	0.788994	312.0095	6.61	16.26
Storage(S)	2	3.840646	1.920323	759.3962	5.79	13.27
PxS	2	0.54165	0.270825	107.0984	5.79	13.27
Error	5	0.012644	0.002529			
Total	11	5.202895				

CD 5%		CD 1%	
P =	0.074644	P =	0.117061
S =	0.09142	S =	0.14337

4.2.4.5 Effect on Taste

As far as taste is concerned, the fresh honey aonla preserve (0^{th} day of storage) scored 7.76 on 9 point scale, showing that the product was rated between 'liked very much' to 'liked moderately'. The effect of storage period on taste score was significant for samples packed in both glass jars and PET jars, which declined

progressively during storage. Effect of packaging material on taste was insignificant as samples packed in both packaging materials were rated as between 'liked moderately' to 'liked slightly' with scores of respectively 6.98 and 6.40 in glass and PET jars, though samples packed in glass jars were better than those packed in PET jars (Tables 4.13 and 4.13.e).

Table 4.13(e): ANOVA for Taste

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	1	0.00099	0.00099			
Pckg. Sys(P)	1	0.522084	0.522084	91.17329	6.61	16.26
Storage(S)	2	2.114688	1.057344	184.6475	5.79	13.27
PxS	2	0.293427	0.146714	25.62108	5.79	13.27
Error	5	0.028631	0.005726			
Total	11	2.959821				

CD 5%		CD 1%	
P =	0.112325	P =	0.176156
S =	0.13757	S =	0.215746

4.2.4.6 Overall Acceptability

With respect to overall acceptability the fresh honey aonla preserve scored 8.15 on 0^{th} day of storage. This score declined significantly with increase in storage period and reached to minimum value of 7.31 in glass jars and 6.53 in PET jars. The effect of packaging material was significant and samples packed in glass jar scored higher than those samples packed in PET jars (Tables 4.13 and 4.13.f).

Table 4.13(f): ANOVA for Overall Acceptability

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	1	0.000833	0.000833			
Pckg. Sys(P)	1	0.618348	0.618348	695.4503	6.61	16.26
Storage(S)	2	3.073058	1.536529	1728.12	5.79	13.27
PxS	2	0.327224	0.163612	184.0129	5.79	13.27
Error	5	0.004446	0.000889			
Total	11	4.023909				

CD 5%		CD 1%	
P =	0	P =	0.069413
S =	0.054209	S =	0.085014

4.2.5 Comparison with Similar Aonla Products

4.2.5.1 Sugar Syrup Segments

Tandon et.al, (2006) have developed an Aonla Murabba substitute which is reported to posses better nutritive properties and is easy to consume and convenient to

eat. In this process aonla fruits are blanched and segmented before dipping in 60°Brix TSS sugar syrup containing 0.5% citric acid and 500 ppm sulphur dioxide. The segment to syrup ratio is kept at 1:1.5 and stored at ambient temperature. Next day the syrup is drained and concentrated to 60°Brix by boiling. The segments are incubated in this syrup overnight and next day the syrup is concentrated to 60°Brix by boiling and TSS is raised to 70°Brix by adding sugar. The segments are again incubated in this syrup overnight. The next day after draining the syrup it is concentrated to 70° Brix by boiling and dipping the segments in syrup overnight. In all segments are kept in sugar syrup for 4 days, i.e., 2 days each in 60°Brix and 70°Brix syrup after concentrating it to respective TSS. Finally, the segments are packed in syrup reconcentrated to72° Brix in airtight plastic jars and stored under ambient conditions.

Depending upon the variety of aonla fruits vitamin C content is reported to be highest (144mg/100g) in the segments of NA-6 aonla fruits while cv Krishna segments were richest in tannins 0.87 % (Table 4.14).

Table 4.14: Chemical and Sensory Qualities of Aonla Segments in Syrup

Variety	Segment/ Syrup	TSS ° Brix	Acidity (%)	Vitamin - C (mg/100g)	Tannins (mg/100g)	Organoleptic Score (out of 9)
Krishna	Segment	65.9	1.04	118	0.87	7.2
	Syrup	66.5	1.07	115	0.93	-
Chakaiya	Segment	66.0	1.01	76	0.49	6.8
	Syrup	65.7	0.84	104	0.46	-
Kanchan	Segment	67.6	1.00	115	0.61	5.5
	Syrup	67.5	0.98	124	0.73	-
NA - 6	Segment	67.4	0.94	144	0.84	6.5
	Syrup	67.9	1.02	161	0.86	-
NA - 7	Segment	65.2	1.01	82	0.50	7
	Syrup	67.2	0.84	97	0.41	-

Source: Tondon et.al, 2006.

The data on sensory evaluation on the basis of colour, texture, and taste indicated that the product scored between 5.5 to 7.2 (on 9 point scale).

Comparing these scores with scores for honey aonla preserves it may be noted that

- Fresh honey aonla murabba had an overall higher average value (8.17±0.024) for all organoleptic characteristics as compared to preserved aonla segments. The segments

had lower vitamin C content (ranging between 76 to 144mg/100g) in comparison to honey aonla murabba which had vitamin C content of 152.1mg/100g which decreased upto minimum value of 119.2mg/100g after 180 days of storage in PET jar.

4.2.6 Effect of storage period and packaging material on Textural Characteristics of Honey Aonla Murabba

Textural profile analysis of honey aonla murabba was conducted using TAHD type texture analyzer (TAHD type, England). The results of texture analysis for honey aonla murabba have been presented in table-4.15 and figure 4.9-4.13. Hardness, cohesiveness and gumminess of the honey aonla murabba was continuously decreasing during storage period upto 6 months in glass jar as well as pet jar. Initially hardness, cohesiveness gumminess was respectively $3.01X10^4$, 1.54 and $4.63X10^4$. After 3 months storage the value of hardness decreased by 2.11 units while after 6 months storage it was 0.73 unit from the storage of 3 months in glass jar bottles. In case of cohesiveness the initial value was 1.54, while after 3 months and 6 months storage it was 1.49 and 1.41 respectively, same trends was observed in gumminess.

Hardness, cohesiveness and gumminess honey aonla murabba were also decreased continuous during 180 days storage when packed in glass jar. While rate of decreasing was slightly low in case of pet jar as compared to glass jar. It was observed that the hardness of glass jar was $1.90X10^4$ in glass jar while $1.86X10^4$ in case of pet jar after 3 months storage. It was also observed that the hardness of glass jar sample was $1.17X10^4$ while in pet jar $0.90X10^4$ after 6 months storage.

The value of cohesiveness was 1.49 in glass jar while 1.19 in pet jar sample just after 3 months storage (difference 0.30 units). These value was 1.41 in glass jar and 0.12 in pet are sample after 6 months storage (difference 1.29 units)

Initial value of gumminess was $4.63X10^4$ while after 3 months storage it was $2.83X10^4$ in glass jar and $2.21X10^4$ in pet jar sample (difference 0.62 units) further it was observed that after 6 months storage value was $1.64X10^4$ in glass jar while $1.08X10^4$ in pet jar (difference 0.56 units).

In general the glass jar was found better packaging material during storage study of 6 months (180 days).

Table 4.15: Textural Characteristics of Honey Aonla Murabba during 6 months of storage

S.No.	Sample	Days	Hardness(g)	Cohesiveness	Gumminess
1	Control	0 days	$3.01X10^4$	1.54	$4.63X10^4$
2	Glass jar	90 days	$1.90X10^4$	1.49	2.8310^4
3	Glass jar	180 days	$1.86X10^4$	1.41	$1.64X10^4$
4	Pet jar	90 days	$1.17X10^4$	1.19	$2.21X10^4$
5	Pet jar	180 days	$0.90X10^4$	0.12	$1.08X10^4$

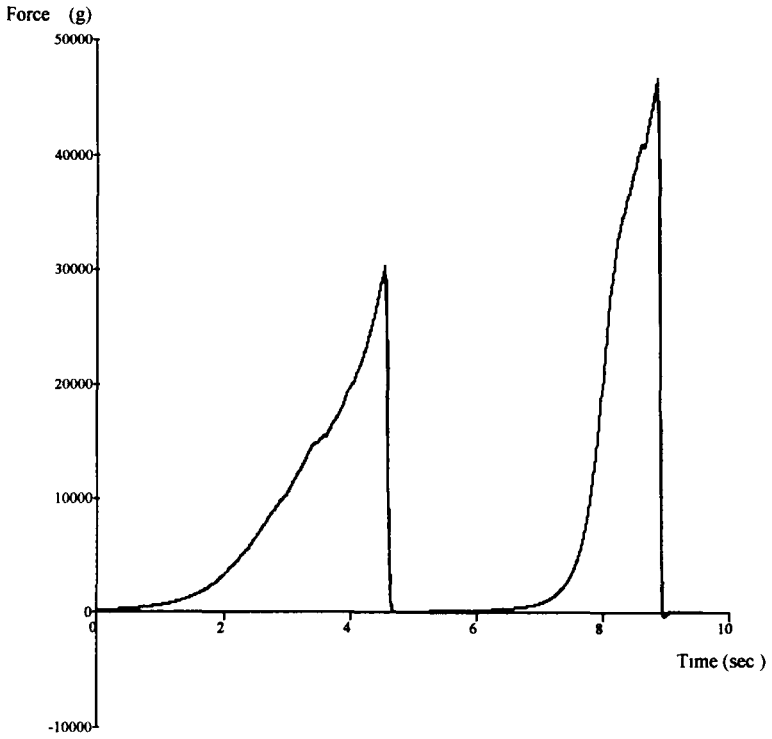


Fig. 4.9 Textural analysis of fresh honey aonla murabba

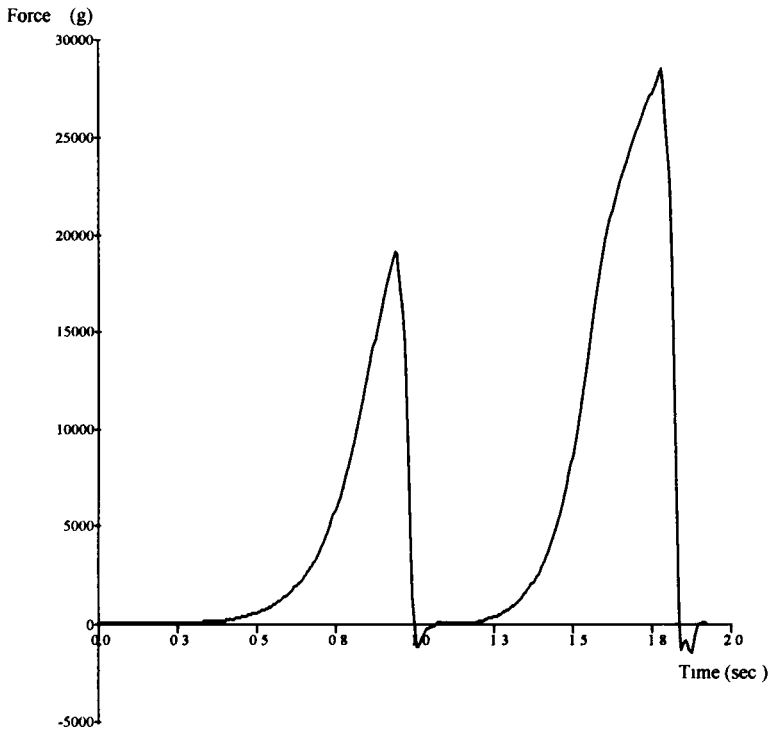


Fig. 4.10 Textural analysis of honey aonla murabba stored in glass jar after 3 months

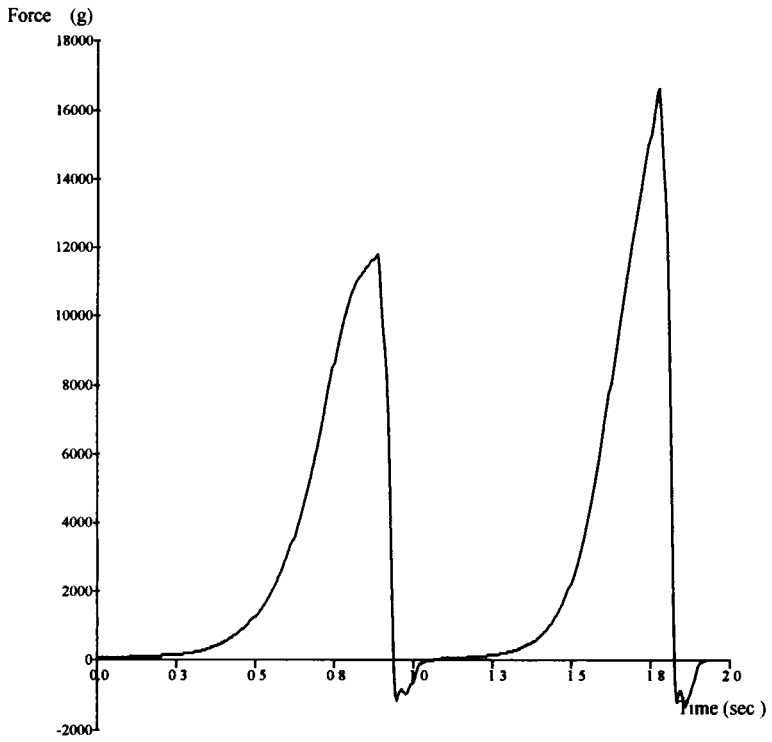


Fig. 4.11 Textural analysis of honey aonla murabba stored in glass jar after 6 month

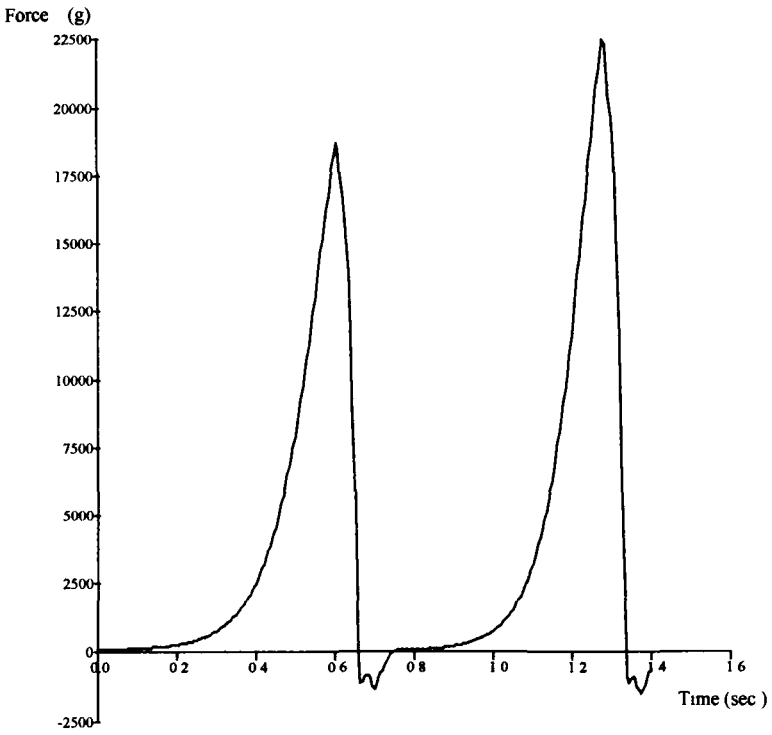


Fig. 4.12 Textural analysis of honey aonla murabba stored in PET jar after 3 months

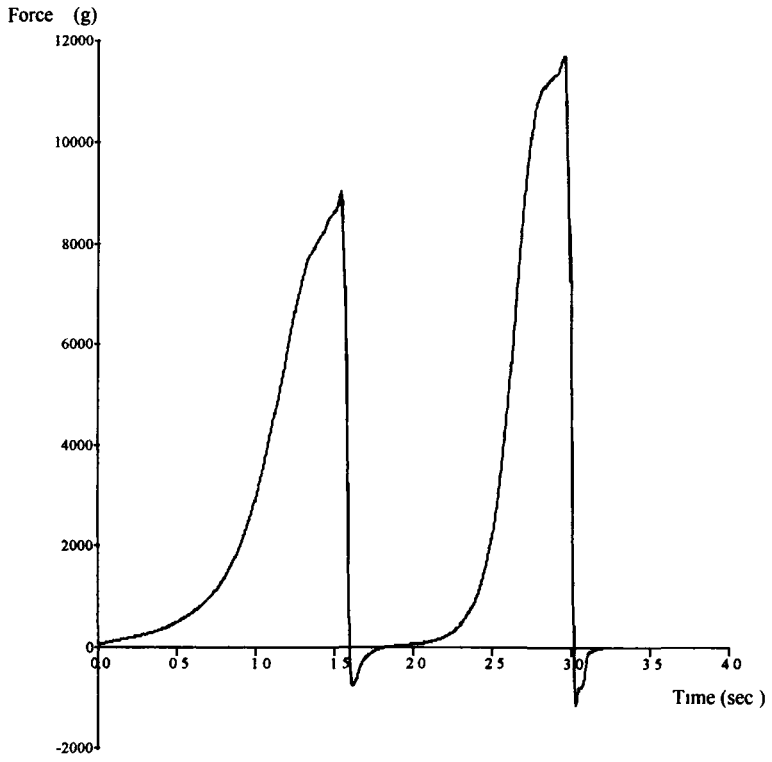


Fig. 4.13 Textural analysis of honey aonla murabba stored in PET jar after 6 months

4.2.7 Economic Analysis

On the basis of results of study relating to manufacturing of honey aonla murabba and its physico-chemical and organoleptic characteristics, the need of its economic feasibility analysis was felt necessary so that it can be transferred to small scale entrepreneurs. The composition of 1000g aonla in 1000g honey was selected keeping in view the composition of murabba and its high acceptability even after 180 days storage at ambient temperatures. The results of economic analysis are presented below:

(a) Assumption Following rational assumptions for small scale honey aonla murabba manufacturing units were made:

(i) Equipments

- **Supply of potable water**

As the quality of water plays a very important role on the overall quality of final product, a submersible pump for supply of potable water was considered necessary. The estimated cost of submersible pump was Rs. 30,000/- and it would have a life of 10 years with additional Rs. 1000/- for electrical fittings.

- **Utensils**

Simple utensils like Bhagona, Karchi and sieve will be required for small scale production of honey aonla murabba. The cost of these utensils is estimated to be approximately Rs. 5000/-. They may have an estimated life of 10 years.

A sum of Rs. 1000/- was considered necessary as miscellaneous charges for all these facilities.

(ii) Raw materials

For small scale production, a production target of 10 kg/h was considered. The average cost of raw aonla was considered to Rs. 10/kg and that of honey was considered to be Rs. 75/kg.

(iii) Packaging material:

The glass bottles have given good results with respect to quality of packaged honey aonla murabba, hence it was considered for economic analysis. The cost of glass bottles was considered to be Rs. 2.50/ bottle of 500g capacity each.

(iv) Space / building:

A working shed of 15'X20' was considered suitable for this cottage industry which was supposed to be hired at a rent of Rs. 1000/month.

(v) Electricity

Electricity used is required for supply of potable water ie operation of submersible pump and for miscellaneous purposes. The prevailing price of Rs. 3/unit (kWh) was considered and consumption of 2 units (kWh) electricity was required per day.

(b) Other assumptions

- **Working days** Keeping in view the seasonal availability of carrots, a total 100 day /y working days for this small scale carrot candy industry were considered.
- **Annual rate of interest on investment** — Assumed at 15% of capital
- **Cost of repair and maintenance** — Assumed at 5% of initial cost
- **Labour required** — One skilled person @ Rs. 150/day
  two unskilled people @ Rs.75/day
- **Cooking fuel** — Ten LPG gas cylinder of 14.5 kg capacity each @400 / cylinder would be required per month.
- **Main product recovery** — 100% product recovery will be obtained

(c) Economic Analysis As the proposed activity is at small scale working capital requirements have been worked out for 6 days only as shown below:

- **Working Capital requirement, Rs / weak of 6 days**

  = Cost of raw materials + Labour charges for 6 days + Rent/ housing for 30 days + Electricity charges for 30 days + Requirement of cooking gas for 6 days + Cost of packaging material for 6 days

  = Rs. (662.5/h X 8 X 6) + Rs. (300/d X 6) + Rs. 1,000/m + Rs. 180/m + Rs. 960 + Rs. 2,400

  = Rs. (31,800 + 1,800 + 1,000 + 180 + 960 + 2400)

  = Rs. 38,140 / week

- **Annual Fixed Costs Rs.**

  = Depreciation + Interest on fixed capital + Maintenance + Rent/ housing Cost + Interest on working capital for the period of operation

  $= \text{Rs. } \frac{(37{,}000 - 3{,}700)}{10} + \text{Rs. } (.15 \text{ X } 37{,}000) + \text{Rs. } (0.05 \text{ X } 37{,}000) +$

  $\text{Rs. } (1{,}000 \text{ X } 12) + \text{Rs. } \frac{(0.15 \text{ X } 38{,}140 \text{ X} 100)}{365}$

= Rs. (3,330 + 5,500 + 1,850 + 12,000 + 1567.39= Rs. 24,297.39

= Say Rs. 24,297.39 / —

- **Capital Investment**

= Initial cost of equipment + 30% of working capital

= Rs. (37,000) + (0.3 X 38,140)

= Rs. (37,000 + 11,442)

= Rs. 48,442 / —

- **Hourly Variable Cost**

= Labour cost + Material cost + Cost of cooking gas + Electricity charges + Maintenance / repair charges + Packaging material cost

= Rs. (300/8) + Rs. 662.50 + Rs. (160/8) +Rs. (6/8) + 0.05 X all Previous charges + Rs. (400/8)

= Rs. (37.5 + 662.50 + 20.0 + 0.75 + (0.05 X 770.75) + 50)

= Rs. (770.75 + 38.53) = Rs. 809.28 **say Rs. 810 / hr**

- **Annual Variable Cost**

= Hourly variable cost X No. of operation hrs. / Year

= Rs. 810 X 8 X 100

= Rs. 6, 48, 000 / —

- **Total Annual Cost**

= Annual (fixed + variable) costs

= Rs. (24,289 + 6, 48,000)

= Rs. 6, 72,298 / —

- **Cost of operation, Rs/h**

$$= \frac{\text{Total annual costs}}{\text{Operation hrs. / Year}}$$

$$= \frac{6,\ 72,298}{8 \text{ X } 100} = \text{Rs. } 840.37 \text{ / hr.}$$

= say Rs. 841 / hr

- **Cost of processing, Rs /kg**

$$= \frac{\text{Hourly cost of processing}}{\text{Capacity per hour}}$$

$$= \frac{\text{Rs. 841}}{18} = \text{Rs. 45 /kg}$$

$$= \textbf{Rs. 45 /kg.}$$

- **Annual Sales Revenue**

= Sale price per kg X Total production per year

= Rs. 65 X 18 kg /hr. X 8 Hrs. / day X100 Days / year

= Rs. 9, 36, 000 / year

- **Annual Net profit**

= Annual sales revenue – Total annual cost

= Rs. 9, 36,000 – 6, 72, 298

= Rs. 2, 63,702 / —

- **Break Even Point (BEP)**

(a) In terms of no. of operation hrs / year

Let BEP occurs at x hours of operation / year

At this stage, Total costs = total revenues

i.e. Fixed cost + hourly variable cost X x = Per hr. sale revenue X x

Rs. 24,298 + 810 X x = Rs. 65 X 18 X x

Rs. 24,298 + 810 x = 1170 x

$$x = \frac{24{,}298}{360}$$

= 67.49 hrs. **say 68 hrs.**

(b) In terms of quantity handled

= x X capacity per hr.

= 68 X 18 kg / hr

= 1224 kg / hr

- **Pay back period**

$$= \frac{\text{Capital Investment}}{\text{Net profit. Rs/ y + Depreciation}}$$

$$= \frac{48{,}442}{2{,}, 63{,}702 + 3{,}330}$$

$$= \textbf{0.18 years}$$

- **Return on Investment, %**

$$= \frac{\text{Net profit, Rs /y}}{\text{Capital investment}} \times 100$$

$$= \frac{2, 63, 702}{48{,}442} \times 100$$

$$= 544.36\ \%\ \textbf{say 545 \%}$$

4.3 Honey Aonla Squash

Squash is a fruit based non-alcoholic beverage containing at least 25% fruit pulp/juice and 40-50% total soluble solids. It also contains about 1.0% acid and 350 ppm sulphurdioxide or 600 ppm sodium benzoate. It is diluted before serving.

Mango, orange and pine apples are normally used for making squash commercially. It can also be prepared from lemon, lime, Bael, guava, litchi, pear, apricot, pummelo, musk melon, papaya etc using potassium metabisulphite (kms) as preservative or from jamun, passion fruit, peach, phalsa, plum, mulberry, raspberry, straw berry, grape fruit etc with sodium benzoate as preservative.

Preparation of beverages from aonla fruits is limited due to high acidity, astringency etc. Singh et.al, (2003) have reported development of aonla squash. 1.0 litre of squash contained 25% aonla pulp, 1.22% acidity, 52% TSS, 5% Asparagus juice and 2.25 % ginger juice. Sodium metabisulphite was used as preservative. This product scored 8 on 9 point hedonic scale and was liked very much. The cost of one litre squash was reported to be Rs. 14.

In this reference, development of honey mixed aonla squash was considered to be a convenient alternative to promote use of aonla as a value-added fruit drink of high quality keeping in view the medicinal and nutritive value of the two products (honey and aonla) and expected improvement in sensory properties.

4.3.1 Optimization of honey concentration in the development of Aonla Squash

Table 4.16(a to d) presents the data related to effect of honey concentration on sensory quality parameters of aonla squash. Decrease in honey concentration with corresponding increase in concentration of juice, keeping the other ingredients viz citric acid and potassium metabisulphite (kms) significantly affected the colour, flavour, taste and overall acceptability of the developed squash. Best results were obtained in treatment T-3 in which 40% honey was mixed in 60% juice. An increase by 5 to 10 % in concentration of honey significantly decreased the colour, flavour and taste with overall decrease in overall acceptability.

Table 4.16: Effect of Honey concentration on organoleptic characteristics of Honey Aonla Squash

	Process condition	**Average grades for sensory quality parameters on 9 point Scale**			
Codes Allotted	**Honey concentration during squash Preparation**	**Colour**	**Flavour**	**Taste**	**Overall Acc.**
T1	50% juice+50% honey +.2% citric acid +350 Ppm kms	7.40±0.54	7.30±0.44	6.80±0.44	7.16±0.33
T2	55% juice+45% honey +.2% citric acid +350 Ppm kms	7.40±0.54	7.30±0.44	7.20±0.44	7.30±0.29
T3	60%juice+40% honey +.2% citric acid +350 Ppm kms	8.00±0.70	7.80±0.44	8.30±0.44	8.03±0.41

Table 4.16(a): ANOVA for Colour

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0086	0.0043	0.2885906		
Treatment	2	0.8978	0.4489	30.127517	6.94	18
Error	4	0.0596	0.0149			
Total	8					

CD(0.05) = 0.338853984
CD(0.01) = 0.561989821

Table 4.16(b): ANOVA for Flavour

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.006688889	0.003344444	0.2926592		
Treatment	2	0.503488889	0.251744444	22.029169	6.94	18
Error	4	0.045711111	0.011427778			
Total	8					

CD(0.05) = 0.296756578
CD(0.01) = 0.492171213

Table 4.16(c): ANOVA for Taste

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.033688889	0.016844444	5.0872483		
Treatment	2	3.877422222	1.938711111	585.51678	6.94	18
Error	4	0.013244444	0.003311111			
Total	8					

CD(0.05) = 0.1597373
CD(0.01) = 0.264924542

Table 4.16(d): ANOVA for Overall Acceptability

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0254	0.0127	15.24		
Treatment	2	1.380066667	0.690033333	828.04	6.94	18
Error	4	0.003333333	0.000833333			
Total	8					

CD(0.05) = 0.080136217
CD(0.01) = 0.132906032

Keeping in view these observations further studies were conducted with T– 3 samples in which juice was 60% and honey was 40% and 2% citric acid was added, along with 350 ppm of potassium metabisulphite (kms). This product scored 8.0, 7.8, 8.3 and 8.03 respectively as scores on 9 point hedonic scale for quality attributes namely colour, flavour, taste and overall acceptability.

4.3.2 Effect of Storage period & Storage temperature on Physico-chemical characteristics of honey aonla squash

Table 4.17 present the related data on various physico – chemical quality attributes of developed honey aonla squash as affected by storage temperature (ambient and refrigerated) and storage period (0 to 180 days).

The total soluble solids (TSS) content of fresh honey aonla squash was 35° Brix (on 0^{th} day of storage / preparation day) which insignificantly decreased up to

34.5°Brix and 34.8°Brix respectively on storage at room and refrigerated storage (Tables 4.17 and 4.17.a).

Table 4.17: Effect of Storage period & Storage temperature on physico-chemical constituents of Honey aonla squash

Storage period (Days)	parameters						
	Storage temp.	TSS °Brix	Acidity (%)	Browning index	Reducing Sugar (%)	Total Sugar (%)	Vitamin C mg/100g
0		35.00±0.0	0.40±0.01	0.08±0.05	23.70±0.15	45.50±0.1	78.60±0.1
30	Room Temp.	35.00±0.0	0.48±0.05	0.11±0.05	24.80±0.05	45.90±0.1	71.80±0.1
	Ref. Temp.	35.00±0.0	0.45±0.01	0.08±0.05	24.10±0.1	45.60±0.1	75.70±0.1
60	Room Temp.	35.00±0.0	0.56±0.01	0.13±0.05	26.00±0.05	46.20±0.13	64.30±0.15
	Ref. Temp.	35.00±0.0	0.49±0.01	0.10±0.01	25.00±0.4	45.90±0.1	69.20±0.1
90	Room Temp.	34.50±0.1	0.64±0.01	0.15±0.01	27.30±0.1	46.80±0.1	56.20±0.1
	Ref. Temp.	34.80±0.1	0.57±0.01	0.11±0.01	25.80±0.1	46.30±0.2	61.00±0.1
120	Room Temp.	34.00±0.0	0.73±0.01	0.18±0.01	27.92±0.03	47.20±0.15	48.10±0.1
	Ref. Temp.	34.60±0.2	0.68±0.01	0.12±0.05	26.40±0.2	46.80±0.05	55.90±0.2
150	Room Temp.	33.50±0.1	0.87±0.02	0.20±0.05	28.40±0.08	47.80±0.1	40.60±0.10
	Ref. Temp.	34.50±0.1	0.77±0.01	0.13±0.01	26.80±0.05	47.00±0.01	47.60±0.2
180	Room Temp.	33.00±0.11	1.02±0.01	0.23±0.007	28.80±0.1	48.50±0.1	34.70±0.1
	Ref. Temp.	34.00±0.11	0.87±0.03	0.15±0.01	27.50±0.10	47.10±0.10	40.10±0.10

Table 4.17(a): ANOVA for Total Soluble Solids

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0033333	0.0016667			
Storage Temp(T)	1	2.0592857	2.0592857	232.78882	4.22	7.72
Storage(S)	6	11.055714	1.842619	208.29607	2.47	3.59
TXS	6	1.6757143	0.2792857	31.571429	2.47	3.59
Error	26	0.23	0.0088462			
Total	41	15.024048				

CD 5%

T = 0.078945

S = 0.1116451

CD 1%

T = 0.1067063

S = 0.1509055

Acidity of the squash on preparation day was 0.4% and it significantly increased upto 0.64 and 0.57% during storage for 90 days at room temperature and refrigerated temperatures respectively.

Table 4.17(b): ANOVA for Acidity

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	3.333E-05	1.667E-05			
Storage Temp(T)	1	0.0460024	0.0460024	209.83542	4.22	7.72
Storage(S)	6	1.4126143	0.2354357	1073.9173	2.47	3.59
TXS	6	0.0189476	0.0031579	14.404623	2.47	3.59
Error	26	0.0057	0.0002192			
Total	41	1.4832976				

CD 5% **CD 1%**

T = 0.0124279 T = 0.0167982

S = 0.0175757 S = 0.0237563

Browning index of the squash was 0.08 on preparation day which insignificantly increased with increase in storage period and reached to maximum level of 0.15 on 90th day on storage at room temperature and upto 0.11 on storage at refrigerated temperature. In all cases the browning index of squash was lower during storage in refrigerated condition as compared to browning index of squash stored at room temperature (Table 4.17.c).

Table 4.17(c): ANOVA for Browning Index

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0002589	0.0001294			
Storage Temp(T)	1	0.0202401	0.0202401	333.38639	4.22	7.72
Storage(S)	6	0.0500406	0.0083401	137.37456	2.47	3.59
TXS	6	0.0077606	0.0012934	21.304815	2.47	3.59
Error	26	0.0015785	6.071E-05			
Total	41	0.0798786				

CD 5% **CD 1%**

T = 0.00654 T = 0.0088399

S = 0.009249 S = 0.0125014

An increase in browning index during storage may be probably due to non-enzymatic browning reaction that would have occurred mainly between sugar and organic acids and among organic acids themselves as suggested by Srivastava and Kumar (1994).

The reducing sugar of squash on the preparation day was 23.7 % which gradually and significantly increased with increase in storage period. The reducing

sugar values were respectively 27.3 and 25.8 % on 90th day of storage at room and refrigerated temperatures. However, in all cases the reducing sugar value of squash was lower at refrigerated temperature as compared to corresponding value in case of storage at room temperature which shows that storage temperature has significant effect on reducing sugar of honey aonla squash (Table 4.17.d). The increase in reducing sugar might be probably attributed to copolymerization with organic acids .

Table 4.17(d): ANOVA for Reducing Sugars

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0006857	0.0003429			
Storage Temp(T)	1	12.672021	12.672021	1056.0663	4.22	7.72
Storage(S)	6	98.276329	16.379388	1365.0323	2.47	3.59
TXS	6	2.9534619	0.4922437	41.022809	2.47	3.59
Error	26	0.311981	0.0119993			
Total	41	114.21448				

CD 5% **CD 1%**

T = 0.0919443 T = 0.1242769

S = 0.1300289 S = 0.175754

Similar increase in total sugars of squash during storage was also observed. On the day of preparation, the total sugar content of honey aonla squash was 45.50% which significantly increased upto 46.80% on 90th day of storage at ambient temperature and upto 46.30% at refrigerated temperature. In this case also the values of total sugar were always slightly lower in case of storage at refrigerated temperature (Table 4.17.e).

Table 4.17(e): ANOVA for Total Sugars

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0016333	0.0008167			
Storage Temp(T)	1	2.5901167	2.5901167	170.27316	4.22	7.72
Storage(S)	6	28.5007	4.7501167	312.27063	2.47	3.59
TXS	6	1.3660333	0.2276722	14.967074	2.47	3.59
Error	26	0.3955	0.0152115			
Total	41	32.853983				

CD 5% **CD 1%**

T = 0.1035223 T = 0.1399263

S = 0.1464027 S = 0.1978857

Vitamin C content of fresh honey aonla squash was 78.60%mg/100g. This value continuously and significantly decreased during storage with increase in period of storage (Table 4.17.f). On 90th day of the storage, the vitamin C content was 56.20

mg/100g in samples stored at room temperature while the corresponding value in case of storage at refrigerated temperature was 61.00mg/100g. At all stages of storage, vitamin C content was higher in samples stored at refrigerated temperature showing a significant effect of storage temperature on vitamin C content of developed squash. Being heat sensitive even the ambient temperature conditions might cause the loss of vitamin C during storage. Participation of vitamin C in non-enzymatic browning might also be a reason for loss of vitamin C during storage.

Table 4.17.f: ANOVA for Vitamin C

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.6894333	0.3447167			
Storage Temp(T)	1	265.40801	265.40801	616.16425	4.22	7.72
Storage(S)	6	8340.6122	1390.102	3227.2243	2.47	3.59
TXS	6	71.388057	11.89801	27.622106	2.47	3.59
Error	26	11.1993	0.4307423			
Total	41	8689.297				

CD 5%		CD 1%	
T =	0.550879	T =	0.7445977
S =	0.7790606	S =	1.0530202

4.3.3 Effect of storage period and storage temperature on organoleptic characteristics of honey aonla squash

Data presented in Table 4.18 and 4.18 (a to d) illustrate the mean sensory scores of developed honey aonla squash for colour, flavour, taste and overall acceptability as affected by storage temperature and storage period (0^{th} to 180 days).

Table 4.18: Effect of storage temperature & storage life on organoleptic characteristics of Honey aonla squash

Parameters	0 days	After 90 days Storage		After 180 days Storage	
		Room Temp	Ref. Temp	Room Temp	Ref. Temp
Colour	7.66±0.57	7.16±0.28	7.50±0.50	6.16±0.28	7.16±0.28
Flavour	7.66±0.57	7.23±0.25	7.66±0.28	6.33±0.28	7.00±0.5
Taste	8.66±0.57	7.03±0.05	7.83±0.28	6.10±0.10	7.00±0.11
O.A.	8.00±0.33	7.14±0.06	7.66±0.16	6.2±0.18	7.05±0.08

*OA Overall Acceptability

The colour score of the developed squash was 7.66 (on 9 point hedonic scale) on preparation day which decreased respectively upto 7.16 and 7.50 in case of storage at room temperature and refrigerated temperature on 90th day. The score further decreased significantly upto 6.16 and 7.16 respectively on storage for 180 days at same temperatures (Table 4.18.a). The decrease in colour with storage period and storage temperature might be due to co – polymerization, interaction between phenolics and protein as well as the formation of cation complexes with proteins during storage.

Table 4.18(a): ANOVA for Colour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	7.778E-05	3.889E-05			
StorageTemp.(T)	1	0.5	0.5	45.848192	4.96	10.04
Storage(S)	2	2.0801778	1.0400889	95.372389	4.1	7.56
TxS	2	0.3333333	0.1666667	15.282731	4.1	7.56
Error	10	0.1090556	0.0109056			
Total	17	3.0226444				

CD 5%		CD 1%	
T =	0.1096814	T =	0.1560055
S =	0.1343317	S =	0.1910669

On the preparation day the score for flavour of developed aonla squash was highest i.e. 7.66(±0.57). This score, however, significantly decreased upto respectively 6.33(±0.28) and 7.00(±0.5) on storage for 180 days at room and refrigerated conditions (Table 4.18 b).

Table 4.18(b): ANOVA for Flavour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0112	0.0056			
StorageTemp.(T)	1	0.6346889	0.6346889	58.695027	4.96	10.04
Storage(S)	2	3.1489	1.57445	145.60265	4.1	7.56
TxS	2	0.3706778	0.1853389	17.139848	4.1	7.56
Error	10	0.1081333	0.0108133			
Total	17	4.2736				

CD 5%		CD 1%	
T =	0.1092166	T =	0.1553445
S =	0.1337625	S =	0.1902573

In all cases, the score for flavour was better/higher in case of samples stored at refrigerated temperature. Similar observations were recorded in other two sensory

quality attributes namely taste and overall acceptability, both of which decreased with increase in storage period, though refrigerated storage was better in retaining these scores as compared to room temperature storage and showing a significant effect of storage temperature. In all cases the samples even after 180 days storage remained acceptable (Table 4.18.c & d).

Table 4.18(c): ANOVA for Taste

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0056444	0.0028222			
StorageTemp.(T)	1	1.5782722	1.5782722	244.23057	4.96	10.04
Storage(S)	2	13.060011	6.5300056	1010.4892	4.1	7.56
TxS	2	0.8091444	0.4045722	62.605743	4.1	7.56
Error	10	0.0646222	0.0064622			
Total	17	15.517694				

CD 5%		CD 1%	
T =	0.0844306	T =	0.12009
S =	0.1034059	S =	0.1470796

Table 4.18(d): ANOVA for Overall Acceptability

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0012	0.0006			
StorageTemp.(T)	1	0.96605	0.96605	161.00833	4.96	10.04
Storage(S)	2	5.6169	2.80845	468.075	4.1	7.56
TxS	2	0.5749	0.28745	47.908333	4.1	7.56
Error	10	0.06	0.006			
Total	17	7.21905				

CD 5%		CD 1%	
T =	0.0813551	T =	0.1157155
S =	0.0996392	S =	0.141722

Increase in acidity and browning index of the samples during storage might have adversely affected all the sensory scores resulting a decline in their scores.

4.3.4 Effect of storage period and storage temperature on microbial quality of honey aonla squash

Table 4.19 presents the data related to various microbial quality attributes of honey aonla squash which was stored at room and refrigerated temperatures for 180 days.

Table 4.19: Effect of storage period on Microbiological quality of Honey aonla squash

Storage period (Days)	Parameters			
	Storage Temperature	TPC (log cfu/g)	Y&M count (log cfu/g)	Coli form count (log cfu/g)
0		ND	ND	ND
30	Room Temp.	ND	ND	ND
	Ref. Temp.	ND	ND	ND
60	Room Temp.	TFTC	TFTC	ND
	Ref. Temp.	TFTC	TFTC	ND
90	Room Temp.	3.71±0.20	TFTC	ND
	Ref. Temp.	2.76±0.11	TFTC	ND
120	Room Temp.	4.58±0.10	3.37±0.15	ND
	Ref. Temp.	3.57±0.18	2.42±0.18	ND
150	Room Temp.	4.93±0.06	3.66±0.14	ND
	Ref. Temp.	4.01±0.01	2.95±0.07	ND
180	Room Temp.	5.61±0.08	4.01±0.02	ND
	Ref. Temp.	4.41±0.10	3.49±0.11	ND

* ND – Not Detected

** TFTC – Too few to count

As may be noted the fresh squash did not show the presence of microorganisms (Total plate count, yeast and mold count and coli form counts). After 90 days of storage, the TPC values of 3.71(±0.20) log cfu/g and 2.76(±0.11) log cfu/g were recorded respectively in samples stored at room and refrigerated temperatures. However with further increase in storage period (during 90 to 180 days) there was significant increase in terms of total plate count and Y & M counts. On the 180th day the samples preserved at room temperature had T P C value of 5.61(±0.08) log cfu/g and values of 4.41(±0.10) at refrigerated temperature. The Y & M count was 3.37(± 0.15) log cfu/g on 120th day at room temperature and 2.42(±0.18) log cfu/g at refrigerated temperature which increased maximum upto 4.01(±0.02) and 3.49(±0.11) log cfu/g on 180th day of storage at room temperature and refrigerated temperature respectively. During entire 180 day storage study the coliform count was not detected in any storage condition.

Table 4.19(a) ANOVA for Total plate count

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0052	0.0026			
Storage Temp. (T)	1	3.5787524	3.5787524	337.04744	4.22	7.72
Storage(S)	6	191.47523	31.912539	3005.5277	2.47	3.59
TXS	6	2.7591476	0.4598579	43.309489	2.47	3.59
Error	26	0.2760667	0.0106179			
Total	41	198.0944				

CD 5%		CD 1%	
T=	0.0864904	T=	0.116905
S=	0.1223159	S=	0.1653287

Table 4.19(b) ANOVA for Yeast and Mould count

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0075	0.00375			
Storage Temp.(T)	1	1.0152595	1.0152595	176.88238	4.22	7.72
Storage(S)	6	115.46199	19.243665	3352.7047	2.47	3.59
TXS	6	1.4913238	0.248554	43.304019	2.47	3.59
Error	26	0.1492333	0.0057397			
Total	41	118.12531				

CD 5%		CD 1%	
T=	0.0635907	T=	0.0859526
S=	0.0899309	S=	0.1215554

The reason for good antimicrobial properties of squash may be presence of honey. There are several reports which deal with antimicrobial activities of honey due to various factors (Molan, 1992). Investigations have already revealed that honey has bactericidal, bacteriostatic and antifungal activities. Nature of antimicrobial factors of honey are due to osmotic effect, acidity, hydrogen peroxide, flavonoids, aromatic acidic substances etc. Growth of bacterial species such as *Escherichia coli, Staphylococcus aureus, Helicobacter pylori, Salmonella typhimurium, Shigella sps, Vibrio cholerae* etc are controlled bacterio statically or by bactericidal activity of honey.

4.3.5 Comparison with similar aonla products

4.3.5.1 Aonla Syrup

Gajanana et.al., (2007) have standardized the recipe for preparation of Aonla syrups. It was reported that the syrup consisting of 55% Aonla juice, 10% lime juice and 4% ginger and remaining sugar adjusted to a TSS of 68 °Brix had highest organoleptic scores ranging between 3.59 to 4.03 with respect to colour and

appearance, taste, flavour and overall acceptability. The product has 141.12mg/100g ascorbic acid content and the sugar to acid ratio was 28.66.

In comparison to this type of product the honey aonla squash has very high scores for all organoleptic characteristics related to colour, flavour, taste and overall acceptability, the mean of which was 8.00(±0.33). Moreover the fresh honey aonla squash has ascorbic acid content 78.60(±0.10) mg/100g, which after 180 days reduced to 34.70(±0.1) and 40.10(±0.10) in room temperature and refrigerated temperature respectively.

4.3.5.1.2 Aonla Squash

Gajanana et.al, (2007) have also standardized recipe for preparation of aonla squash. The squash consisting 30% aonla juice, 5% lime juice, 2% ginger and sugar adjusted to a TSS of 40°Brix was found to have the highest organoleptic scores (ranging between 3.04 to 3.65) with respect to colour and appearance, taste, flavour and overall acceptability. The mean of all these scores works out to be 3.3 while the honey aonla squash had the average score of 8.00(±0.33) in fresh which even after 180 days storage at room and refrigerated temperatures scored a mean value of 6.2 ± 0.18 and 7.05±0.08 respectively. As these values are significantly higher than score of aonla squash, the honey aonla squash may be considered as significantly more acceptable product. In this case also the ascorbic acid was significantly higher in honey aonla squash (78.6±0.10 mg/100g in fresh and 34.70±0.1 and 40.10± 0.10mg/100g after 180 days of storage in room and refrigerated temperatures respectively) as compared to aonla squash which had ascorbic acid content of 51.28mg/100g.

4.3.6 Economic Analysis

On the basis of results of study, a combination of 60% of Aonla fruit juice and 40% of honey was found the best among all treatments for production of best quality of honey based squash. Therefore, for economic analysis of honey based squash manufacturing at small scale, the above described composition was selected with following rational assumption.

Assumptions

- Production target = 10 lt /hr, 80 lt / day or 80,000/year of 100 working days.
- Equipment & utensils required

(i) Screw type hand operated juice extractor = Rs. 1,700

(ii) Crown corking machine = Rs. 4,000

(iii) Utensils = Rs. 5,000

Total **= Rs.10,700**

- Life of equipment & other utensils = 10 years
- Cost of annual repair & maintenance = 5 % of initial cost
- Annual rate of interest on investment = 15 % of initial cost
- Labour requirement = One skilled and two unskilled @ Rs.150 /d/person and Rs. 75/d/person respectively
- Working hours and days / year = 8 h /day, 100 days / year
- Working Capital = variable cost for 25 days per month
- Sale price of squash = Rs. 70/kg

Raw materials requirement, kg/h

(i) Honey @ Rs. 75 /kg = Rs. 300 /hr.

(ii) Aonla fruit @Rs.10/kg = Rs.120/hr.

- Cost of packaging material

Glass bottles @ Rs. 5/ bottle = Rs.400/day, Rs. 40,000/year.

- Cost of cooking gas (LPG) cylinder = Rs. 400/cylinder of 14.5 kg
- No. of cooking gas cylinder required /m = 2.
- Main product recovery = 100%
- Rent of building (20'X20') = Rs. 1000/ month

Calculations

- **Working Capital requirement, Rs / month of 25 days**

= Cost of raw materials/month + Labour charges for 25 days + Rent of housing for 30 days + Requirement of cooking gas for 25days + Cost of packaging material for 25 days production

= Rs. (420 /h X 8 X25) + Rs. (300 X25) + Rs. 1000 + Rs. (400X2)
+ Rs. (400X25)

= Rs.84,000 + Rs.7500 + Rs.1000 + Rs.800 + Rs.10,000

= Rs.1,03,300/ —

- **Annual Fixed Costs Rs.**

= Depreciation + interest on fixed capital + maintenance + rent/ housing cost + Interest on working capital for the period of operation

$$= \frac{Rs.(10,700-10,70)}{10} + Rs.(0.15x10,700) + Rs.(0.05x10,700)$$

$$+ Rs.(1000x12) + \frac{Rs.(0.15x1,03,300z100}{365}$$

= Rs. (963 + 1,605 + 535 + 12,000 + 4245.20)

= Rs. 19,348.2 **say Rs.19, 348 / —**

- **Capital investment**

= Initial cost of equipment + 30% of working capital

= Rs. (10,700) + (0.3 X1, 03,300)

= Rs. (10,700 + 30,990)

= Rs. 41,690/ —

- **Hourly variable cost**

= Labour cost + Material cost + Cost of cooking gas + Packaging material cost + Maintenance / repair charges

= Rs. (300/8) + Rs.420 + Rs. (192 / 8 X6) + Rs. (400/ 8) + 0.05 X all previous charges

= Rs. 37.5 + Rs. 420+Rs. 4.0 + Rs.50 + 0.05 X 511.5

= Rs. (511.5 + 25.5) = **Rs. 537 / —**

- **Annual variable cost**

= Hourly variable cost X No. of operation hrs / year

= Rs. 537 X 8 X100 = **Rs. 4, 29,600 / —**

- **Total Annual cost**

= Annual (fixed + variable) costs

= Rs. (19,348 + 4, 29,600)

= Rs. 4, 48,948 / —

- **Cost of operation, Rs/hr.**

$$= \frac{\text{Total annual costs}}{\text{operation hrs/year}}$$

$$= \frac{4,48,948}{8 \times 100} = \text{Rs.561.18 /hr } \textbf{say Rs. 561/hr}$$

- **Cost of processing, Rs/kg**

$$= \frac{\text{Hourly cost of processing}}{\text{Capacity per hour}}$$

$$= \frac{\text{Rs. 561}}{10} = \text{Rs, 56.1 } \textbf{say Rs. 56 /lt}$$

- **Annual sales revenue**

= Sale price / lt X Total Production

= 70 X 10 lt/hr X 8 hrs./ day X 100 days/year

= Rs. 5, 60,000/ year

- **Annual net profit**

= Annual sales revenue – total annual cost

= Rs. (5, 60,000 – 4, 48,948)

= Rs. 1, 11,052/ —

- **Break even point (BEP)**

(a) In terms of no. of operation hrs /year

Let BEP occurs at x hours of operation /year

At this stage, total costs = total revenues

i.e. Fixed cost + hourly variable cost X x = per hr. sale revenue X x

Rs. 19,348 + Rs. 537 X x = 70 X 10 X x

Rs. 19,348 + Rs. 537 x = 700 x

so x = 19,348 / 163 = 118.69 hrs.

= say Rs. 119 hrs.

(b) In terms of quantity handled

= x X capacity per hr.

= 119 X 10 lt /hr = **1190 lt/year**

- **Pay back period**

$$= \frac{\text{Capital investment}}{\text{Net profit Rs./y + Depreciation}}$$

$$= \frac{41{,}690}{1{,}11{,}052 + 1{,}070}$$

= 0.37 years

- **Return – on – investment**

$$= \frac{\text{Net profit, Rs/y}}{\text{Capital investment, Rs}} \times 100$$

$$= \frac{\text{Rs } 1{,}11{,}052}{\text{Rs } 41{,}690} \times 100$$

= 266.3 **say 266 %**

Above economic analysis and economic indications suggest that manufacturing of honey aonla squash on small scale has good economic viability.

4.4 Honey Mixed Fruit jam

Jam is an important type of preserved fruits used since long time and which finds wide acceptability due to simple and economical process. The method is based on the formation of gel by the pectin present in the fruit in presence of proper proportion of acids and sugar, when heated. In jam, the fruit tissues are held in position by the gel. The pectic substances present in fruits include protopectin, pectin and pectic acid. The protopectin present in unripe fruits inhibits gel formation while

the pectin present in properly mature fruits forms a solution with water. Pectin is extracted when the fruit is heated with a small amount of water because some of the pectic substances of the fruits remain in the solid portion. When sugar is added to the pectin solution, it acts as a dehydrating agent and destabilizes the pectin-water equilibrium and the conglomerates forming a network of insoluble fibres. Large amounts of sugar solution can be held in this mesh type structure.

Usually in the preparation of jams, ripe fruits are selected, thoroughly washed (to remove dust/dirt), chopped, meshed or diced depending upon the nature of the fruit and type of jam required. If the fruit has little or no juice of its own, a small quantity of water is added followed by addition of proper quantity of sugar (sucrose). The finished product should contain 30-50 % invert sugar to avoid the crystallization of cane sugar in the jam during storage. If the fruit is deficient in acid and pectin, commercial preparations are added before mixing the sugar then the mixture is immediately heated with constant stirring. When done, it is packed in jars or cans. When packed in cans, the sealed cans are pasteurized for about 30 min.

Jams have characteristic texture, colour and flavour. Its texture should be such that it can be easily spread and the fruit pieces in the product should be easily recognizable without being tough and should not be disintegrated. As it is a preserve, it should be capable of storage for a reasonable period without spoilage.

The sugars present in jam comprise the natural sugars originating from the fruit together with the added sugars. These together constitute about two- thirds of the product. The bulk of the added sugar is sucrose which may be from cane or beet sugars. During the boiling process some of the sucrose is converted to invert sugar, a mixture of dextrose and fructose. This conversion is accelerated by increase in temperature and by decrease in pH. This change results in an increase in sugar solids since 19 parts of sucrose plus one part of water together yield 20 parts of invert sugars. Inversion is advantageous since a solution of sucrose is saturated at approximately 66% at 20°C and may crystallize at higher concentrations.

Glucose syrup may be incorporated into the recipe upto that level of reducing sugars in the finish product. But the use of glucose syrup influences the setting characteristics of the jam by raising the setting temperature. Because of simple sugars jams are a good source of quick energy. However because of intense cooking most of the vitamin C and other nutrients in fruits are destroyed in jam making.

Honey seems to be a potential replacement of sugar in jam manufacturing as it is mostly sugars-fructose and glucose with small quantity of sucrose and it also contains B complex and C vitamins. Jam was prepared from mixed fruits of papaya and guava using honey in place of sugar. The study pertained to optimization of ingredients based on sensory characteristics of jam and effect of packaging material and storage period on various qualities attributes of jam. Results of the study are presented below:

4.4.1 Effect of Honey concentration on organoleptic characteristics of jam

The sensory scores of mixed fruit (papaya and guava) jam are presented in Table 4.20. As evident from Table 4.20, treatment T1 consisting of 750g honey mixed

Table 4.20: Effect of Honey concentration on organoleptic characteristics of honey mixed fruit jam

Codes Allotted	Process Condition	Average Grades for Quality Parameters on 9 Point Scale				
	Honey Concentration during jam preparation	Colour	Flavour	Taste	Texture	O A*
T1	750 gm honey + 1k g mixed pulp	8.78±0.19	8.06±0.11	8.57±0.18	7.63±0.15	8.26±0.07
T2	1000 gm honey + 1k g mixed pulp	8.17±0.14	8.00±0.1	7.96±0.05	7.53±0.57	7.91±0.03
T3	1250 gm honey + 1k g mixed pulp.	8.13±0.15	8.00±0	7.89±0.08	7.48±0.10	7.87±0.04

* O A Overall Acceptability

in 1000g (1 kg) of mixed pulp with pulp: honey ratio of 1:33:1 were highest, with an overall acceptability score of 8.26(±0.07) and therefore selected for further studies. The corresponding average scores for colour, flavour, taste and texture were respectively 8.78(±0.19), 8.06(±0.11), 8.57(±0.18), and 7.63(±0.15), for jam thus prepared. Further addition of honey or pulp honey ratio of 1:1 or 0.8:1 critically / significantly affected all sensory scores (Tables 4.20.a to 4.20.e).

Table 4.20(a): ANOVA for Colour

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0050889	0.0025444	0.064507		
Treatment	2	0.7916222	0.3958111	10.034648	6.94	18
Error	4	0.1577778	0.0394444			
Total	8					

CD(0.05)= 0.551331
CD(0.01)= 0.9143832

Table 4.20(b): ANOVA for flavour

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0155556	0.0077778	1		
Treatment	2	0.0088889	0.0044444	0.5714286	6.94	18
Error	4	0.0311111	0.0077778			
Total	8					

CD(0.05) = 0.2448202
CD(0.01) = 0.4060346

Table 4.20(c): ANOVA for taste

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0156222	0.0078111	0.4431138		
Treatment	2	0.8222889	0.4111444	23.323668	6.94	18
Error	4	0.0705111	0.0176278			
Total	8					

CD(0.05) = 0.3685685
CD(0.01) = 0.6112714

Table 4.20(d): ANOVA for texture

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0216667	0.0108333	0.8125		
Treatment	2	0.035	0.0175	1.3125	6.94	18
Error	4	0.0533333	0.0133333			
Total	8					

CD(0.05)= 0.3205449
CD(0.01) = 0.5316241

Table 4.20(e): ANOVA for overall acceptability

SOURCE	df	SS	MSS	F ratio	Ftable 5%	Ftable 1%
Replication	2	0.0004222	0.0002111	0.0432802		
Treatment	2	0.2712889	0.1356444	27.808656	6.94	18
Error	4	0.0195111	0.0048778			
Total	8					

CD(0.05)= 0.1938789
CD(0.01)= 0.3215484

4.4.2 Effect of storage period and storage temperature on Physico – chemical characteristics of honey mixed fruit jam

The developed jam prepared by treatment T1 was packed in glass jars and stored at room temperature (25-30°C) and at refrigerated temperature (4°C) for 180 days. The changes in important physico-chemical characteristics of jam during storage are presented below:

4.4.2.1 Effect on Moisture content

The fresh jam (0^{th} day of storage) had moisture content of 29.1(±0.1)% which increased gradually during storage, affected by both, the temperature of storage and period of storage. In case of storage at room temperature, the moisture content increased upto 29.8% on 60^{th} day, upto 31.3% on 120^{th} day and upto 32% on 180^{th} day of storage. These changes in moisture content were significant and resulted due to honey content in jam (honey being hygroscopic which absorbs moisture from atmosphere). Contrary to this finding, Koli et.al, (2004) reported insignificant decrease in moisture content of sapota jam. (Table 4.21 & Table 4.21.a)

Table 4.21: Effect of storage period & storage temperature on physico-chemical constituents of honey mixed fruit jam

Parameters	Storage period (Days)						
	0	60		120		180	
		Room Temp	Ref,Temp	Room Temp	RefTemp	Room Temp	RefTemp
Moisture Content,%	29.1±0.1	29.8±0.05	29.4±0.5	31.3±0.2	29.7±0.15	32.0±0	30.0±0.2
TSS,°Brix	71.5±0.2	70.2±0.1	71.0±0.1	69.0±0	70.5±0.3	68.5±0.1	70.0±0.3
Acidity,%	0.42±0.0	0.62±0.02	0.51±0.01	0.81±0.01	0.68±0.01	0.92±0.0	0.80±0.05
Browning Index	0.42±0.01	0.51±0.01	0.48±0.01	0.72±0.02	0.57±0.01	1.11±0.08	0.72±0.02
Reducing Sugars,%	30.5±0.08	31.42±0.1	31.0±0.3	32.1±0.14	31.9±0.1	33.7±0.1	32.8±0.05
Total Sugars,%	65.8±0.11	66.24±0.2	66.0±0.11	66.8±0.15	66.5±0.5	67.5±0.1	67.0±0.5
Vit. C mg/100g	18.2±0.06	16.4±0.10	17.1±0.01	14.4±0.2	15.1±0.05	12.2±0.17	13.8±0.15
Vit. A (IU)	49.6±0.12	46.83±0.1	47.1±0.15	43.7±0.1	44.6±0.05	39.19±0.2	40.2±0.3

Table 4.21(a): ANOVA for Moisture Content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.035425	0.0177125			
S. Temp. (T)	1	6.30375	6.30375	104.06623	4.6	8.86
Storage(S)	3	13.143133	4.3810444	72.32501	3.34	5.56
TXS	3	3.99125	1.3304167	21.963347	3.34	5.56
Error	14	0.8480417	0.0605744			
Total	23	24.3216				

CD 5% **CD 1%**

T = 0.2155243 T = 0.3011312

S = 0.3047974 S = 0.4258638

The jam sample which was stored at refrigerated condition also showed increase in moisture content though this change was significant. The moisture content increased upto 29.4(±0.5)%, 29.7(±0.15)% and 30.0(±0.2)% respectively on 60,120 and 180 days of storage. The increases in moisture content values were by 0.3, 0.6 and 0.9% after 60, 120 and 180 days storage. Thus the storage of honey mixed jam of guava and papaya at ambient condition resulted in significant increase in moisture content affected by storage period but in case of refrigerated storage the change was insignificant.

4.4.2.2 Effect on TSS Content

The fresh jam has TSS content of 71.5(± 0.2) °Brix, which decreased during storage. The decrease in TSS was significant both in case of storage at ambient temperatures and under refrigerated conditions, though TSS decreased more in case of product stored at room temperature. Koli et.al, (2004) have reported increase in TSS content of sapota jam while Tripathi et.al, (1988) have also reported decrease in TSS of aonla jam during storage. The decrease in TSS of mixed fruit jam during storage may be due to increase in acidity and other solids because of the presence of honey. Gulati and Kumari (2005) have reported decrease in TSS of honey with increase of storage period. (Table 4.21 and Table 4.21.b).

Table 4.21(b): ANOVA for TSS

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0558333	0.0279167			
S. Temp. (T)	1	5.6066667	5.6066667	147.86813	4.6	8.86
Storage(S)	3	17.19	5.73	151.12088	3.34	5.56
TXS	3	2.41	0.8033333	21.186813	3.34	5.56
Error	14	0.5308333	0.0379167			
Total	23	25.793333				

CD 5% **CD 1%**

T = 0.1705166 T = 0.2382463

S = 0.2411469 S = 0.3369312

4.4.2.3 Effect on Acidity

The fresh honey mixed fruit jam had acidity of 0.42% which significantly increased during storage at both, ambient temperature and refrigerated temperature (Table 4.21 and 4.21.c). However higher percent increase in acidity was observed during storage at ambient temperatures. The increase in acidity of guava pulp during storage has been reported by Tandon et.al, (1983).

Table 4.21(c): ANOVA for Acidity

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.002149	0.0010745			
S. Temp. (T)	1	0.0509682	0.0509682	129.60362	4.6	8.86
Storage(S)	3	0.6745473	0.2248491	571.75411	3.34	5.56
TXS	3	0.0172618	0.0057539	14.631329	3.34	5.56
Error	14	0.0055057	0.0003933			
Total	23	0.750432				

CD 5% **CD 1%**

T = 0.0173657 T = 0.0242634

S = 0.0245588 S = 0.0343137

4.4.2.4 Effect on Browning Index

The fresh honey mixed jam had browning index of 0.42 which significantly increased with increase in storage period (Table 4.21 and Table 4.21.d). However the browning index of samples stored at refrigerated temperature was lower as compared to corresponding values in samples stored at room temperature. At the end of 120 days storage the browning index of samples stored at room temperature was almost three times of value in fresh condition while in samples stored at refrigerated temperature an increase by 0.3 units only was noted. This showed that temperature of storage significantly affected the browning index of product.

Table 4.21(d): ANOVA for Browning Index

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0060726	0.0030363			
S. Temp. (T)	1	0.1248484	0.1248484	151.97061	4.6	8.86
Storage(S)	3	0.8692985	0.2897662	352.71534	3.34	5.56
TXS	3	0.1451351	0.0483784	58.888159	3.34	5.56
Error	14	0.0115014	0.0008215			
Total	23	1.156856				

CD 5% **CD 1%**

T = 0.0250994 T = 0.035069

S = 0.0354959 S = 0.049595

4.4.2.5 Effect on Reducing and Total sugars

The reducing sugars and total sugars in fresh honey mixed jam were respectively 30.5 and 65.8%, both of which insignificantly increased during storage (Table 4.21 and Table 4.21.e, Table 4.21.f).

Table 4.21(e): ANOVA for Reducing sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.1352333	0.0676167			
S. Temp. (T)	1	0.8855042	0.8855042	66.000311	4.6	8.86
Storage(S)	3	25.520512	8.5068375	634.05	3.34	5.56
TXS	3	0.6183125	0.2061042	15.361801	3.34	5.56
Error	14	0.1878333	0.0134167			
Total	23	27.347396				

CD 5% **CD 1%**

T = 0.1014318 T = 0.1417207

S = 0.1434462 S = 0.2004234

Table 4.21(f): ANOVA for Total sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.1795083	0.0897542			
S. Temp. (T)	1	0.375	0.375	4.864001	4.6	8.86
Storage(S)	3	7.1163333	2.3721111	30.767869	3.34	5.56
TXS	3	0.2051333	0.0683778	0.8869055	3.34	5.56
Error	14	1.0793583	0.077097			
Total	23	8.9553333				

CD 5% **CD 1%**

T = 0.2431479 T = 0.3397269

S = 0.343863 S = 0.4804464

The changes in reducing sugars may be attributed to inversion of non-reducing sugars to reducing sugars by acid hydrolysis. Increase in reducing sugar content of guava papaya fruit bar and guava fruit bar have been earlier reported. Tripathi et.al, (1988) has also reported increase in reducing and total sugars of aonla jam during storage.

4.4.2.6 Effect on Vitamin C content

Vitamin C content of honey mixed jam was 18.2mg/100g on 0^{th} day of storage which significantly decreased during storage (Table 4.21 and Table 4.21.g). Higher decrease was observed in case of jam stored at room temperature during all stages of storage period. Loss in vitamin C during storage is in conformity to results of Veeranan et.al, (2005) for mixed fruit (mango, papaya and banana) bar.

Table 4.21(g): ANOVA for Vit C content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0006333	0.0003167			
S. Temp. (T)	1	3.6738375	3.6738375	220.21004	4.6	8.86
Storage(S)	3	93.595112	31.198371	1870.0322	3.34	5.56
TXS	3	2.0548458	0.6849486	41.055861	3.34	5.56
Error	14	0.2335667	0.0166833			
Total	23	99.557996				

CD 5%		CD 1%	
T=	0.1131079	T=	0.1580347
S=	0.1599588	S=	0.2234949

4.4.2.7 Effect on Vitamin A content

Vitamin A content of honey mixed jam on 0^{th} day (fresh) was 49.6 IU, which significantly decreased during storage with in storage period. Higher decrease in vitamin A content was observed in samples stored at ambient temperatures than in samples stored at refrigerated temperature. This shows that temperature significantly affects the vitamin A content of stored product (Table 4.21.h).

Table 4.21(h): ANOVA for Vit. A content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0081333	0.0040667			
S. Temp. (T)	1	1.8537042	1.8537042	78.404406	4.6	8.86
Storage(S)	3	325.37745	108.45915	4587.396	3.34	5.56
TXS	3	1.0637125	0.3545708	14.996954	3.34	5.56
Error	14	0.331	0.0236429			
Total	23	328.634				

CD 5% **CD 1%**

T= 0.1346485 T= 0.1881313

S= 0.1904218 S= 0.2660579

4.4.3 Effect of storage period and storage temperature on organoleptic characteristics of honey mixed fruit jam

The sensory qualities of honey mixed guava-papaya jam in terms of colour, taste, texture and overall acceptability were evaluated on 9 point hedonic scale. In other study also, the jam samples were packed in glass bottles stored at room temperature and under refrigerated temperature. The effects of storage temperature and storage period on above sensory characteristics are reported below (Table 4.22).

Table 4.22: Effect of storage period and storage temperature on organoleptic characteristics of honey mixed fruit jam

Parameters	0 days	After 90 days Storage		After 180 days Storage	
		Room temp	Ref. temp	Room temp	Ref. temp
Colour	8.78±0.1	8.03±0.05	8.32±0.11	7.20±0.10	7.53±0.07
Flavour	8.08±0.01	7.90±0.1	8.00±0	7.03±0.05	7.53±0.09
Taste	8.57±0.09	7.82±0.06	8.20±0.1	7.2 0± 0.1	7.55±0.09
Texture	7.63±0.11	7.20±0.10	7.43±0.1	7.01±0.01	7.20±0.1
O.A.*	8.26±0.02	7.74±0.01	7.98±0.02	7.11±0.03	7.45±0.03

OA* Overall Acceptability

4.4.3.1 Effect on Colour

The score for colour of fresh sample (0^{th} day of storage) was 8.78 on 9 point scale. This score decreased significantly during storage up to 8.03 and 8.32 in case of 90 days storage at room temperatures and refrigerated temperatures respectively (Table 4.22.a). During further storage of 180 days (additional days), the score further

decreased up to 7.20 and 7.53 respectively in samples stored at room temperatures and refrigerated temperatures. In all cases the score for colour was slightly higher for samples stored at refrigerated condition.

Table 4.22(a): ANOVA for Colour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0727444	0.0363722			
S. Temp.(SS)	1	0.1922	0.1922	59.586635	4.96	10.04
Storage(S)	2	6.0056444	3.0028222	930.9473	4.1	7.56
PxS	2	0.0977333	0.0488667	15.149845	4.1	7.56
Error	10	0.0322556	0.0032256			
Total	17	6.4005778				

CD 5%		CD 1%	
T =	0.0596501	T =	0.0848434
S =	0.0730562	S =	0.1039116

4.4.3.2 Effect on Flavour

The average score of fresh (0^{th} day of storage) honey incorporated mixed jam was 8.08 on 9 point scale. This score decreased with increase in storage period. The decrease was insignificant during first 90 days but became significant during 90 to 180 days storage period (Table 4.22.b). In this study also the score for samples kept at refrigerated temperature was always higher than scores for samples stored at ambient temperatures showing that temperature of storage as well as storage period both significantly affected the flavour characteristics of honey jam.

Table 4.22(b): ANOVA for flavour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0024778	0.0012389			
S. Temp.(SS)	1	0.1780056	0.1780056	40.466027	4.96	10.04
Storage(S)	2	2.1291444	1.0645722	242.00935	4.1	7.56
PxS	2	0.2070111	0.1035056	23.529932	4.1	7.56
Error	10	0.0439889	0.0043989			
Total	17	2.5606278				

CD 5%		CD 1%	
T =	0.0696595	T =	0.0990803
S =	0.0853151	S =	0.1213481

4.4.3.3 Effect on Taste

The fresh honey incorporated mixed jam scored 8.57 on 9 point scale showing that the product was very much liked in fresh condition (Table 4.22.c). An insignificant decrease in this important characteristic was observed during 90 day

storage period, irrespective of storage temperature, though samples stored in refrigerated conditions were better than samples stored at ambient temperature. Similar observations were recorded during further storage of 180 days. At the end of 180 days storage the samples of honey incorporated mixed jam remained highly acceptable scoring 7.2 to 7.55 on 9 point scale.

Table 4.22(c): ANOVA for Taste

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0076778	0.0038389			
S. Temp.(SS)	1	0.26645	0.26645	28.944478	4.96	10.04
Storage(S)	2	4.2780111	2.1390056	232.36029	4.1	7.56
PxS	2	0.1336333	0.0668167	7.2582981	4.1	7.56
Error	10	0.0920556	0.0092056			
Total	17	4.7778278				

CD 5%		CD 1%	
T =	0.1007706	T =	0.1433313
S =	0.1234183	S =	0.1755443

4.4.3.4 Effect on Texture

With respect to texture the honey incorporated fresh jam scored 7.63 on a 9 point scale which decreased insignificantly on storage for 90 days and 180 days at both ambient and refrigerated temperatures (Table 4.22.d). The samples stored at refrigerated temperature scored little higher than the samples stored at ambient temperatures showing that storage period and storage temperatures did not significantly affect the texture of honey incorporated jam.

Table 4.22(d): ANOVA for Texture

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0397	0.01985			
S. Temp.(SS)	1	0.0868056	0.0868056	11.497425	4.96	10.04
Storage(S)	2	0.8484333	0.4242167	56.187638	4.1	7.56
PxS	2	0.0444111	0.0222056	2.9411332	4.1	7.56
Error	10	0.0755	0.00755			
Total	17	1.09485				

CD 5%		CD 1%	
T =	0.0912604	T =	0.1298044
S =	0.1117707	S =	0.1589773

4.4.3.5 Effect on Overall acceptability

The overall acceptability of freshly prepared honey incorporated mixed jam was very high as evident from score of 8.26 on 9 point scale. Though this score decreased with increase in storage period and was affected by storage temperature. The decrease was insignificant during first 90 days of storage as indicated by score of 7.74 and 7.98 respectively for samples stored at room temperatures and refrigerated temperatures. Similarly the score decreased insignificantly up to 7.11 and 7.45 respectively for samples stored in ambient temperature and refrigerated condition during further storage of 180 days (additional 90 days). At the end of 180 days storage the samples remained in acceptable conditions (Table 4.22.e).

Table 4.22(e): ANOVA for Overall Acceptability

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	1.8007444	0.9003722			
S. Temp.(SS)	1	0.1701389	0.1701389	0.5150643	4.96	10.04
Storage(S)	2	1.0057444	0.5028722	1.5223534	4.1	7.56
PxS	2	0.0920778	0.0460389	0.1393743	4.1	7.56
Error	10	3.3032556	0.3303256			
Total	17	6.3719611				

CD 5%		CD 1%	
T =	0.6036428	T =	0.8585925
S =	0.7393084	S =	1.0515567

4.4.4 Effect of storage period and storage temperature on microbial characteristics of honey mixed fruit jam

The fresh samples did not show presence of any microbes as indicated by TPC, Y & M count and coliform count. Their presence was not detected (Table 4.23 and Table 4.23.a & b) while no coliform count was recorded during 180 days storage, irrespective of storage temperatures, The TPC was too few to be detected during first 60 days of storage but a count of 2.78 and 2.12 log cfu / g was recorded on storage at room temperatures and refrigerated conditions respectively during 60 to 120 days storage. This count further increased respectively up to 3.24 and 2.75 at above temperatures during further storage for 180 days. From TPC point of view the samples stored at refrigerated temperature were slightly better as compared to samples stored at room temperatures. Similar results were observed in case of yeast and mould count which were detected after 120 days storage. However, from both counts of

view, the samples stored for 180 days irrespective of storage temperatures remained in safe limit.

Table 4.23: Effect of storage period and storage temperature on Microbiological characteristics of honey mixed fruit jam

	Storage period (days)						
Parameter	**0**	**60**		**120**		**180**	
		Room Temp	**Ref Temp**	**Room Temp**	**Ref Temp**	**Room Temp**	**Ref Temp**
TPC (log cfu/g)	ND *	TFTC**	TFTC	2.78±0.12	2.12±0.05	3.24±0.02	2.75±0.01
Y&Mcoun (log cfu/g)	ND	TFTC	TFTC	TFTC	TFTC	2.95±0.04	2.74±0.05
Coliform count (log cfu/g)	ND	ND	ND	ND	ND	ND	ND

* ND – Not Detected

** TFTC – Too few to count

Table 4.23 (a): ANOVA for TPC

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0055083	0.0027542			
S. Temp.(SS)	1	0.5162667	0.5162667	196.27246	4.6	8.86
Storage(S)	3	45.614717	15.204906	5780.5479	3.34	5.56
TxS	3	0.5462667	0.1820889	69.225918	3.34	5.56
Error	14	0.036825	0.0026304			
Total	23	46.719583				

CD 5% **CD 1%**

T= 0.0449117 T= 0.0627507

S= 0.0635147 S= 0.0887429

Table 4.23(b): ANOVA for Y & M

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.000675	0.0003375			
S. Temp.(SS)	1	0.01215	0.01215	6.3648269	4.6	8.86
Storage(S)	3	36.04005	12.01335	6293.2423	3.34	5.56
TxS	3	0.03645	0.01215	6.3648269	3.34	5.56
Error	14	0.026725	0.0019089			
Total	23	36.11605				

CD 5% **CD 1%**

T= 0.0382601 T= 0.0534572

S= 0.054108 S= 0.0755999

4.4.5 Economic Analysis

On the basis of results of study relating to manufacturing of honey mixed fruit jam and its physico-chemical and sensory characteristics, the need of its economic feasibility analysis was felt necessary so that it can be transferred to small scale entrepreneurs. The composition of 1000g mixed fruit pulp in 750g honey was selected keeping in view the composition of jam and its high acceptability even after 180 days sample preservation at ambient and refrigerated temperatures. The results of economic analysis are presented below:

Assumptions

- Production target = 10 lt /hr, 80 lt / day or 80,000/year of 100 working days.
- Equipment & utensils required

(i) Open pan evaporator	= Rs. 1,45,000
(ii) Mixer grinder	= Rs. 2,000
(iii) Utensils	= Rs. 5,000
(iv) Electrical fittings	= Rs. 1,000
Total	**= Rs.1,53,000**

- Life of equipment & other utensils = 10 years
- Cost of annual repair & maintenance = 5 % of initial cost
- Annual rate of interest on investment = 15 % of initial cost
- Labour requirement = One skilled and two unskilled @ Rs.150 /d/person and Rs. 75/d/person respectively
- Working hours and days / year = 8 h /day, 100 days / year
- Working Capital = variable cost for 25 days per month
- Sale price of jam = Rs. 105/kg

Raw materials requirement, kg/h

(i) Honey @ Rs. 75 /kg	= Rs. 450 /hr.
(ii) Guava fruit @Rs.8/kg	= Rs.32/hr.
(iii) Papaya fruit @ Rs.12/kg	= Rs.60/hr.

- Cost of packaging material
  Glass bottles @ Rs. 2.50/ bottle of 500 gm capacity = Rs.400/day, Rs. 40,000/year.
- Cost of cooking gas (LPG) cylinder = Rs. 400/cylinder of 14.5 kg
- No. of cooking gas cylinder required /m = 2.
- Main product recovery = 100%
- Electric power consumption @ Rs 3/kwh (unit) = 60 units/day for operation of open pan and grinder
- Rent of building (20'X20') = Rs. 1000/ month

Calculations:

- **Working Capital requirement, Rs / month of 25 days**

= Cost of raw materials + Labour charges for 6 days + Rent/ housing for 30 days + Electricity charges for 30 days + Requirement of cooking gas for 6 days + Cost of packaging material for 6 days

= Rs. (542 /h X 8 X25) + Rs. (300 X25) + Rs. 1000 +Rs (180X30) + Rs. (400X2) + Rs. (400X25)

= Rs 1,08, 400 + Rs.7500 + Rs.1000+5,400+ Rs.800 + Rs.10,000

= Rs.1, 33,100/ —

- **Annual Fixed Costs Rs.**

= Depreciation + interest on fixed capital + maintenance + rent/ housing cost + Interest on working capital for the period of operation

$$= \frac{\text{Rs.}(1,53,000\ 15,300)}{10} + \text{Rs}(0.15 \text{ X } 1,53,000) + \text{Rs.}(0.05 \text{ X } 1,53,000)$$

$$++ \text{Rs.}(1000 \text{ X } 12) + \frac{\text{Rs.}(0.15 \text{ X } 1,33,100 \text{ X } 100)}{365}$$

= Rs. (13,770+ 22,950 + 7,650 + 12,000 + 5469.8)

= Rs. 61839.8 **say Rs.61, 728 / —**

- **Capital investment**

  = Initial cost of equipment + 30% of working capital

  = Rs. (1, 53,300) + (0.3 X1, 33,100)

  = Rs. (1, 53,300+ 39,930)

  = Rs. 1, 93,230/ —

- **Hourly variable cost**

  = Labour cost + Material cost + Cost of cooking gas +

  Packaging material cost + Electricity charges+ Maintenance / repair charges

  = Rs. (300/8) + Rs.542 + Rs. (32 / 8) + Rs. (400/ 8) +180/8

  + 0.05 X all previous charges

  = Rs. 37.5 + Rs. 542+Rs. 4.0 + Rs.50 +22.5 + 0.05 X 656

  = Rs. (656 + 32.8) = **Rs. 688.8 say 689 / —**

- **Annual variable cost**

  = Hourly variable cost X No. of operation hrs / year

  = Rs. 689X 8 X100 = **Rs. 5,51,200 / —**

- **Total Annual cost**

  = Annual (fixed + variable) costs

  = Rs. (61, 728 + 5,51,200)

  = Rs. 6,12,928 / —

- **Cost of operation, Rs/hr.**

$$= \frac{\text{Total annual costs}}{\text{operation hrs/year}}$$

$$= \frac{6,12,928}{8 \text{ X } 100} = \text{Rs.766.1 /hr } \textbf{say Rs. 766/hr}$$

- **Cost of processing, Rs/kg**

$$= \frac{\text{Hourly cost of processing}}{\text{Capacity per hour}}$$

$$= \frac{\text{Rs. 766}}{10} = \text{Rs, 76.6 } \textbf{say Rs. 77/kg}$$

- **Annual sales revenue**

= Sale price / lt X Total Production

= 105X 10 kg/hr X 8 hrs./ day X 100 days/year

= Rs. 8,40,000/ year

- **Annual net profit**

= Annual sales revenue – total annual cost

= Rs. (8, 40,000 – 6, 12,928)

= Rs. 2, 27,072/ —

- **Break even point (BEP)**

(a) In terms of no. of operation hrs /year

Let BEP occurs at x hours of operation /year

At this stage, total costs = total revenues

i.e. Fixed cost + hourly variable cost X x = per hr. sale revenue X x

Rs. 61,728 + Rs. 689 X x = 105 X 10 X x

Rs. 61,728 + Rs. 689 x = 1050 x

so x = 61,728 / 163 = 361 hrs.

= 361 hrs/

(b) In terms of quantity handled

= x X capacity per hr.

= 361X 10 kg /hr = **3610 kg/year**

- **Pay back period**

$$= \frac{\text{Capital investment}}{\text{Net profit Rs./y + Depreciation}}$$

$$= \frac{1,93,230}{2,27,072 + 15,300}$$

= **0.91 years**

- **Return – on – investment**

$$= \frac{\text{Net profit, Rs/y}}{\text{Capital investment, Rs}} \text{X } 100$$

$$= \frac{\text{Rs } 2,27,072}{\text{Rs } 1,93,230} \times 100$$

$$= 117.5 \text{ say } \mathbf{118\ \%}$$

Above economic analysis and economic indications suggest that manufacturing of honey based mixed fruit jam on small scale has good economic viability.

4.5 Honey Toffee

The name 'toffee' was originally used for products which did not contain milk and were similar to butter scotch. The name is still used in this context for Toffee Apples but most toffees these days do contain milk. Toffees are now made by boiling sugar, glucose syrup, milk (usually condensed milk), vegetable fats and salt. Other ingredients may include cream, butter and various flavouring additions such as treacle or malt extract. Many toffees are still made with brown sugars because of the flavour they impart. Emulsifiers are frequently added, the usual ones being glyceryl monostearate or lecithin. Fruits are also used as ingredient in toffee known as 'Fruit toffees'. They contain nutrients like vitamins and minerals present in the original fruit. Such toffees are nutritionally superior to those prepared from sugar or its syrup alone. In this reference honey-milk and honey-milk-chicory toffees were prepared in present study to take advantages of nutritional and medicinal properties of honey and honey - chicory combined.

The results of the study are presented below:

4.5.1 Yield, composition and characteristics of honey-skim milk toffee

Table 4.24 and 4.25 present the data related to yield, and chemical composition and organoleptic characteristics of honey based toffees. It may be noted that out of three different treatments (T1, T2, T3) related to use of honey in varying proportions with skim milk powder and hydrogenated fat, the highest yield (1.403 kg) per kg honey was obtained in treatment T3 followed by treatments T2 (1.385 kg) and T1 (1.367 kg) respectively.

From the organoleptic characteristics point of view, the best quality toffees were, however, obtained in treatment T2. The respective scores for various quality attributes namely colour, flavour, taste, texture and overall acceptability of toffees produced by this treatment on 9 point hedonic scale were respectively 8.0, 8.0, 8.6,

7.6 and 8.0. Highest score of 8.6 was awarded for taste followed by scores of 8 to 8.0 for colour, flavour and over all acceptability. Lowest score of 7.6 was awarded to only textural characteristics. Decrease in percentage of honey (treatment T3) resulted in poorer scores for all characteristics. Similarly increase in percentage of honey (treatment T1) also resulted in poorer scores of all characteristics.

Table 4.24: Ingredients level (g/kg honey) used for honey Toffee

Treatments	Honey (g)	Milk powder (g)	Hydrogenated Fat (g)	Chicory (g) (roasted and powdered)	yield kg /kg raw material
T1	1000	380	120	—	1367
T2	1000	400	120	—	1385
T3	1000	420	120	—	1403
T4	1000	380	120	20	1385
T5	1000	400	120	30	1413
T6	1000	420	120	40	1439

Table 4.25: Organoleptic characteristics of honey toffee prepared by different combinations of Ingredients

Treatments	Honey % age in combination of toffee	Average score on 9 point - hedonic scale				
		Colour	Flavour	Taste	Texture	Overall Acceptability
T1	66.66	7.66± 0.57	7.66± 0.57	7.00±0.0	7.33±0.57	7.41±0.14
T2	65.78	8.00±0	8.00±0	8.66±0.57	7.66±0.57	8.08±0.28
T3	64.93	7.66±0.57	7.66±0.57	7.33±0.57	7.33±0.57	7.50±0
T4	65.78	7.00±0	716±0.28	7.00±0.50	6.86±0.23	7.00±0.13
T5	64.51	7.66±0.57	8.16±0.28	8.83±0.28	7.33±0.52	8.00±0.33
T6	63.29	6.83±0.28	7.33±0.57	7.50±0.50	6.83±0.28	7.12±0.12
Mean	65.15	7.46	7.66	7.72	7.22	7.51
SE±	1.18	0.45	0.38	0.81	0.31	0.44
CD at 5%		0.68	0.76	0.93	1.81	0.46

Keeping in view the scores of this organoleptic characteristics, the treatment T2 consisting of 65.78% honey as ingredient was considered best with average score of 8.0(±0.28) in comparison to treatment T1 (average score 7.4±0.14) and treatment T3 (average score 7.5). Based on these observations incorporation of 65.78% honey in composition of toffee was considered optimal and further studies were carried out for toffees prepared by this treatment only. Fresh toffees prepared by this treatment had moisture content of 7.83%, fat content of 14.6%, reducing sugar content of 27.99% and total sugar content of 67.43% with pH and browning index values of 6.50 and 0.25 respectively.

4.5.2 Yield, composition and characteristics of honey-skim milk and chicory toffee

Similarly for toffees prepared with additional use of roasted chicory powder, different proportions of chicory were used (treatments T4, T5, T6). Highest yield of toffees per kg honey (1.439kg) was obtained in treatment T6 followed by treatments T5 (1.413kg) and T4 (1.385kg) respectively. Treatment T5 in which honey was 64.51 % in composition gave best overall acceptability score of 8.0±0.33 (on 9 point hedonic scale) followed by treatments T6 and T4 (average score 7.12±0.13 and 7.00±0.12 respectively). Toffees prepared by this treatment (T5) obtained highest score of 8.83 for taste followed by score of 8.16 for flavour. Lowest score of 7.33 was obtained for texture. Based on these observations in corporation of 64.51 % honey in composition of toffee was considered optimal and further studies were carried out for toffees prepared by this treatment only. Fresh toffees prepared by this treatment had moisture content of 9.10%, fat content of 15.40%, reducing sugar content of 29.43% and total sugar content of 69.00% with pH and browning index values of 6.60 and 0.48 respectively.

4.5.3 Effect of storage temperature and storage period on physico-chemical composition of honey-skim milk toffee

The toffees were packed in plastic wrapping and stored at room temperatures varying between 25 to 35°C and refrigerated temperature of 4°C in domestic refrigerator. The effects of storage temperature and storage period on various qualities attributes were recorded for 180 days duration (Table 4.26) as discussed below:

Table 4.26: Effect of Storage period and Storage temperature on physico-chemical constituents of honey toffee

Storage period (Days)	parameters						
	Storage Temp.	Moisture Content (%)	pH	Fat Content (%)	Browning index	Reducing Sugar (%)	Total Sugar (%)
0		7.83±0.09	6.50±0.10	14.6±0.10	0.25±0.07	27.99±0.10	67.43±0.09
30	Room Temp.	8.21±0.20	6.40±0.05	14.06±0.15	0.34±0.01	28.89±0.10	67.78±0.20
	Ref. Temp.	7.36±0.09	6.40±0.05	14.21±0.10	0.29±0.01	28.76±0.20	67.68±0.10
60	Room Temp.	8.99±0.11	6.30±0.05	13.60±0.20	0.45±0.01	29.70±0.15	68.40±0.10
	Ref. Temp.	7.01±0.02	6.35±0.09	13.80±0.10	0.32±0.00	29.58±0.10	68.30±0.10
90	Room Temp.	9.37±0.09	6.20±0.05	13.20±0.10	0.52±0.01	30.65±0.01	68.92±0.12
	Ref. Temp.	6.75±0.05	6.30±0.10	13.40±0.10	0.39±0.01	29.98±0.02	68.78±0.04
120	Room Temp.	9.88±0.10	6.11±0.02	12.70±0.15	0.59±0.01	31.00±0.20	69.41±0.07
	Ref. Temp.	6.33±0.07	6.20±0.10	13.00±0	0.45±0.04	30.86±0.10	69.10±0.15
150	Room Temp.	10.41±0.28	6.03±0.05	12.25±0.18	0.66±0.01	31.68±0.10	69.70±0.10
	Ref. Temp.	6.02±0	6.08±0.17	12.70±0.1	0.50±0.05	31.20±0.05	69.48±0.10
180	Room Temp.	11.10±0.20	5.96±0.05	11.63±0.15	0.70±0.10	32.25±0.27	70.23±0.06
	Ref. Temp.	5.40±0.20	6.00±0	12.40±0.1	0.57±0.01	31.86±0.15	69.83±0.15

4.5.3.1 Effect on Moisture content

The moisture content of toffees on 0^{th} day of storage was 7.83% which gradually and significantly increased with increase in storage period at room temperatures while an increase in moisture content by 1.54% was noted after 90 days storage (Table.4.26.a). The increase was by 3.27% at the end of 180 days storage. Such increase in moisture content in honey toffees during ambient storage is obvious due to hygroscopic nature of honey as well as of milk powder. Siva Kumar et.al, (2007), had however reported significant decrease in moisture content of guava toffees prepared in sugar solution.

Table 4.26(a): ANOVA for moisture content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0943321	0.0471661			
Storage Temp(T)	1	78.050834	78.050834	4706.388	4.22	7.72
Storage(S)	6	1.1536036	0.1922673	11.593526	2.47	3.59
TXS	6	35.722737	5.9537895	359.00761	2.47	3.59
Error	26	0.4311845	0.016584			
Total	41	115.45269				

CD 5%		CD 1%	
T =	0.1080917	T =	0.1461026
S =	0.1528648	S =	0.2066202

In contrast to storage of toffees in ambient conditions, when the toffees were stored at refrigerated temperature, decrease in moisture content from initial value of 7.83% to 5.4% at the end of 180 days (decrease by 2.43%) was noted. Storage at refrigerated conditions did not allow the toffees to gain moisture from atmosphere.

4.5.3.2 Effect on pH

A continuous and significant decrease in pH value of toffees was observed during storage for 180 days. The fresh toffees had pH value of 6.50 which decreased to 6.4 during first 30 days of storage at both, room temperature as well as refrigerated temperature. Marginal change in pH of toffees stored at these two temperature conditions was observed during storage of 30 to 180 days (Table 4.26.b). For example, the toffees had pH values of 6.3 on 60^{th} day of storage at room temperature while the corresponding value was 6.35 on refrigerated temperature. Similarly on 90^{th} day of storage at room temperature the pH was 6.20 while its value on refrigerated temperature was 6.3. On the 180^{th} day of storage, the pH value of toffees stored on room temperature was 5.96 and that of toffees stored at refrigerated temperature was 6.0. In all cases, the pH value was higher in case of toffees stored at refrigerated temperature. As the toffees consisted mostly of honey the change in pH during storage is linked to behavior of honey during storage. In this reference Kaushik et.al, (1993) have reported that the pH of honey decreases from 4.1 to 3.7 during storage and is consistent with increase in acidity. It was further reported by them that the acidity of honey increases significantly after 2, 4 and 6 months. Decrease in pH of guava toffee has been reported with increase in storage period by Siva Kumar et. al, (2007).

Table 4.26(b): ANOVA for pH

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0015857	0.0007929			
Storage Temp(T)	1	0.0224024	0.0224024	3.0250278	4.22	7.72
Storage(S)	6	1.2432952	0.2072159	27.980677	2.47	3.59
TXS	6	0.0130476	0.0021746	0.29364	2.47	3.59
Error	26	0.1925476	0.0074057			
Total	41	1.4728786				

CD 5% **CD 1%**

T = 0.072232 T = 0.0976327

S = 0.1021515 S = 0.1380735

4.5.3.3 Effect on Fat content

The fat content of fresh honey toffee (on 0^{th} day of storage) was14.6% due to presence of hydrogenated fat and milk powder in its composition. A significant decrease in fat content with increase in period of storage was noted during 180 days of storage. Storage temperature had marginal effect on fat content of toffees (Table. 4.26.c).

Table 4.26 (c): ANOVA for Fat content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0406048	0.0203024			
Storage Temp(T)	1	0.9093429	0.9093429	58.224901	4.22	7.72
Storage(S)	6	30.504795	5.0841325	325.53521	2.47	3.59
TXS	6	0.5603571	0.0933929	5.9799116	2.47	3.59
Error	26	0.4060619	0.0156178			
Total	41	32.421162				

CD 5% **CD 1%**

T = 0.1048955 T = 0.1417824

S = 0.1483447 S = 0.2005106

Toffees preserved at refrigerated temperature had slightly higher fat content as compared to toffees preserved at room temperature. The difference in fat contents of toffees preserved at room temperature and at refrigerated temperature on 30^{th} day of storage was by 0.155% which gradually increased to 0.20% on 60^{th} and 90^{th} day, to 0.30% on 120^{th} day, to 0.355 on 150^{th} day and 0.77% on 180^{th} day of storage.

4.5.2.4 Effect on Browning index

The fresh toffees (on 0^{th} day of storage) had browning index value of 0.25. A significant increase in this value of toffees was observed with increase in storage

period. For example on 60th day of storage at room temperatures , the browning index value of toffees was 0.45, on 150th day this value was 0.66 and on 180th day the value of browning index was 0.70 showing an increase by 0.45 units during 180 days (almost tripled) (Table 4.26 d) . In case of storage of toffees at refrigerated temperatures also increase in value of browning index was noted though the increase in this case was always smaller as compared to storage of toffees on room temperatures. After 180 days of storage of toffees at refrigerated temperature, the browning index was 0.57 showing an increase by 0.32 units in 180 days. In all cases the value of browning index was lower at refrigerated temperature as compared to corresponding value at room temperature. This showed that storage of toffees at refrigerated temperature as compared to storage at room temperature resulted in lesser changes in values of browning index. Increase in browning index in honey toffees is obvious due to non enzymatic reactions and presence of sugar which supports the formation of brown pigment. It is well known that the colour of honey (dominating in composition of toffee) is significantly affected by the storage temperature and period

Table 4.26(d): ANOVA for Browning index

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0127773	0.0063887			
Storage Temp(T)	1	0.1129449	0.1129449	106.91901	4.22	7.72
Storage(S)	6	0.7151406	0.1191901	112.83105	2.47	3.59
TXS	6	0.0291558	0.0048593	4.6000476	2.47	3.59
Error	26	0.0274653	0.0010564			
Total	41	0.8974839				

CD 5%		CD 1%	
T =	0.0272806	T =	0.0368739
S =	0.0385805	S =	0.0521475

(Gupta et.al, 1992). As already explained in the case of carrot candy, the period of storage of honey (and its products) significantly increases the colour intensity of honey which could be attributed to the maillared reaction resulting in formation of coloured pigments ad higher colloid contents.

4.5.2.5 Effect on Reducing sugar

The fresh honey based toffees (on 0th day of storage) had reducing sugar content of 27.99 % which significantly increased upto 32.25 % at room temperature and upto 31.86 % on refrigerated temperature at the end of 180 days storage . The

increase in reducing sugar with increase in storage period was gradual but continuous (Table.4.26.e).

Table 4.26(e): ANOVA for Reducing sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0375762	0.0187881			
Storage Temp(T)	1	0.7872024	0.7872024	37.148555	4.22	7.72
Storage(S)	6	75.664067	12.610678	595.10549	2.47	3.59
TXS	6	0.525981	0.0876635	4.1368931	2.47	3.59
Error	26	0.5509571	0.0211907			
Total	41	77.565783				

CD 5%		CD 1%	
T =	0.1221855	T =	0.1651525
S =	0.1727964	S =	0.2335609

Interestingly the toffees stored at refrigerated temperatures in all cases of observation, had lower value of reducing sugar as compared to corresponding values at room temperature stored toffees, though the difference in these values was not significant. The increase in reducing sugars of toffees may be attributed to increased inversion of sugar component during storage as reported by Rani and Bhatia (1985).

4.5.2.6 Effect on Total sugar

The total sugar content of honey based toffees was 67.43% on 0^{th} day of storage (in fresh toffees) which gradually increased with increase in period of storage. The storage temperature did not affect much the total sugar content. For example on 180^{th} day of storage the total sugar content of toffees stored at room temperature was 70.23% (showing an increase by 2.80% during 180 days) while the corresponding value was 69.83% (showing an increase of 2.40% during 180 days) in case of toffees stored at refrigerated temperature.

Table 4.26 (f): ANOVA for Total sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0111762	0.0055881			
Storage Temp(T)	1	0.3241929	0.3241929	23.908222	4.22	7.72
Storage(S)	6	33.495733	5.5826222	411.70114	2.47	3.59
TXS	6	0.1585238	0.0264206	1.9484402	2.47	3.59
Error	26	0.3525571	0.0135599			
Total	41	34.342183				

CD 5%		CD 1%	
T =	0.0977407	T =	0.1321116
S =	0.1382263	S =	0.186834

Similar increase in total sugar content of carrot candy prepared with honey has been earlier observed in present investigation. Probably the increase in colloidal content of honey with increase in storage period may be the factor for such increase in total sugar content of toffees (Table.4.26.f).

4.5.4 Effect of storage temperature and storage period on physico-chemical composition of honey-skim milk, chicory toffee

The chicory mixed honey toffee had higher moisture content, pH, fat content, browning index, reducing sugar and total sugar (Table 4.27) due to addition of chicory powder. The change pattern in all these characteristics during 180 days storage was similar as stated in case of honey toffee.

Table 4.27: Effect of Storage period & Storage temperature on physico-chemical constituents of honey chicory toffee

Storage period (Days)	parameters						
	Storage Temp.	Moisture Content (%)	pH	Fat Content (%)	Browning index	Reducing Sugar (%)	Total Sugar (%)
0		9.10±0.05	6.60±0.15	15.40±0.05	0.48±0.01	29.43±0.10	69.00±0.50
30	Room Temp.	9.70±0.05	6.50±0.15	15.00±0.05	0.52±0.02	29.83±0.02	69.30±0.05
	Ref. Temp.	8.70±0.05	6.55±0.10	15.20±0.03	0.50±0.05	29.68±0.08	69.19±0.00
60	Room Temp.	10.30±0.20	6.40±0.10	14.70±0.05	0.58±0.01	30.68±0.01	69.74±0.10
	Ref. Temp.	8.20±0.11	6.50±0.05	15.00±0.04	0.56±0.01	30.01±0.05	69.47±0.10
90	Room Temp.	10.90±0.05	6.30±0.10	14.30±0.20	0.66±0.01	31.71±0.10	70.00±0.50
	Ref. Temp.	7.64±0.03	6.40±0.20	14.70±0.05	0.60±0.0	30.56±0.11	69.80±0.10
120	Room Temp.	11.50±0.10	6.20±0.05	13.92±0.02	0.72±0.04	32.33±0.15	70.64±0.03
	Ref. Temp.	7.06±0.05	6.30±0.05	14.41±0.01	0.67±0.01	31.01±0.01	70.10±0.05
150	Room Temp.	12.10±0.05	6.10±0.03	13.33±0.15	0.81±0.01	32.77±0.02	71.21±0.05
	Ref. Temp.	6.54±0.01	6.20±0.05	14.00±0	0.71±0.01	31.60±0.10	70.50±0.20
180	Room Temp.	13.00±0.03	6.00±0.10	12.90±0.05	0.90±0	34.32±0.10	71.20±0.20
	Ref. Temp.	5.80±0.05	6.10±0	13.60±0.10	0.77±0.02	32.20±0.05	71.00±0.01

Table 4.27(a): ANOVA for moisture content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0082429	0.0041214			
Storage Temp(T)	1	118.74249	118.74249	19109.676	4.22	7.72
Storage(S)	6	0.3189143	0.0531524	8.554013	2.47	3.59
TXS	6	58.818914	9.8031524	1577.6583	2.47	3.59
Error	26	0.1615571	0.0062137			
Total	41	178.05011				

CD 5% **CD 1%**

T =	0.0661643	T =	0.0894313
S =	0.0935705	S =	0.1264749

Table 4.27(b): ANOVA for pH

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0037476	0.0018738			
Storage Temp(T)	1	0.0656095	0.0656095	5.4479203	4.22	7.72
Storage(S)	6	1.4481571	0.2413595	20.041411	2.47	3.59
TXS	6	0.0141571	0.0023595	0.1959243	2.47	3.59
Error	26	0.313119	0.012043			
Total	41	1.8447905				

CD 5% **CD 1%**

T =	0.0921119	T =	0.1245033
S =	0.1302658	S =	0.1760743

Table 4.27(c): ANOVA for Fat content

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0027571	0.0013786			
Storage Temp(T)	1	1.6205357	1.6205357	233.07233	4.22	7.72
Storage(S)	6	21.683062	3.6138437	519.75835	2.47	3.59
TXS	6	0.5665476	0.0944246	13.580548	2.47	3.59
Error	26	0.1807762	0.0069529			
Total	41	24.053679				

CD 5% **CD 1%**

T =	0.0699893	T =	0.0946012
S =	0.0989798	S =	0.1337864

Table 4.27(d): ANOVA for Browning index

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0011762	0.0005881			
Storage Temp(T)	1	0.0319277	0.0319277	73.960679	4.22	7.72
Storage(S)	6	0.6221339	0.103689	240.19595	2.47	3.59
TXS	6	0.0204863	0.0034144	7.9094272	2.47	3.59
Error	26	0.0112238	0.0004317			
Total	41	0.6869479				

CD 5%		CD 1%	
T =	0.0174394	T =	0.023572
S =	*0.024663*	S =	*0.0333358*

Table 4.27(e): ANOVA for Reducing sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0021143	0.0010571			
Storage Temp(T)	1	9.3154381	9.3154381	1188.3158	4.22	7.72
Storage(S)	6	68.016824	11.336137	1446.0845	2.47	3.59
TXS	6	4.8214619	0.803577	102.5076	2.47	3.59
Error	26	0.203819	0.0078392			
Total	41	82.359657				

CD 5%		CD 1%	
T =	0.0743161	T =	0.1004497
S =	0.1050989	S =	0.1420573

Table 4.27(f): ANOVA for Total sugar

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.3984333	0.1992167			
Storage Temp(T)	1	1.3572024	1.3572024	26.35935	4.22	7.72
Storage(S)	6	26.488495	4.4147492	85.742496	2.47	3.59
TXS	6	0.742781	0.1237968	2.4043605	2.47	3.59
Error	26	1.3387	0.0514885			
Total	41	30.325612				

CD 5%		CD 1%	
T =	0.1904594	T =	0.2574352
S =	0.2693503	S =	0.3640683

4.5.5 Effect of storage temperature and storage period on micro-biological properties of honey toffee

Table 4.28 presents the data related to effect of storage period and temperature on microbial properties of developed honey toffees. The toffees on 0^{th} day of storage did not show presence of any microbes. TPC value of 2.76 log cfu/g was observed on

90^{th} day of storage at room temperature which increased maximum upto 4.56 log cfu/g on 180^{th} day of storage. Corresponding values for toffee stored at refrigerated temperature were respectively 1.90 and 3.21 log cfu/g, showing that storage of toffee at refrigerated temperature in comparison to storage at room temperatures was better from control of microbial counts point of view. During 90 days storage the Y & M counts were too few to count (TFTC). These microbes appeared on storage for 120 days and increased during remaining period of storage. In this case also refrigerated storage was better as compared to storage at room temperatures. No coliform counts were detected during entire period of storage of toffee. In all cases the product remained under safe limits showing that toffees could be preserved for 180 days without any danger to human safety. Increases in microbial counts of guava toffee with storage period have been reported by Siva Kumar et.al, 2007.

Table 4.28: Effect of Storage period & Storage temperature on microbiological properties of honey toffee

Storage period (Days)	parameters			
	Storage Temp.	TPC (log cfu/g)	Y&M count (log cfu/g)	Coliform count (log cfu/g)
0		ND	ND	ND
30	Room Temp.	ND	ND	ND
	Ref. Temp.	ND	ND	ND
60	Room Temp.	TFTC	TFTC	ND
	Ref. Temp.	TFTC	TFTC	ND
90	Room Temp.	2.76±0.20	TFTC	ND
	Ref. Temp.	1.90±0.50	TFTC	ND
120	Room Temp.	3.51±0.11	2.85±0.05	ND
	Ref. Temp.	2.42±0.60	2.00±0.15	ND
150	Room Temp.	3.99±0.05	3..42±0.06	ND
	Ref. Temp.	2.85±0.50	2.02±0.50	ND
180	Room Temp.	4.56±0.15	3.89±0.20	ND
	Ref. Temp.	3.21±0.25	2.25±0.30	ND

* ND – Not Detected

** TFTC – Too few to count

4.5.6 Effect of storage temperature and storage period on micro-biological properties of honey skim milk chicory toffee

The chicory mixed honey toffee had higher Total plate count, Yeast and mould count (Table 4.29) due to addition of chicory powder. The change pattern in all these characteristics during 180 days storage was similar as stated in case of honey toffee. No coliform counts were detected during entire period of storage of toffees. The change pattern in all these characteristics during 180 days storage was similar as stated in case of honey toffee. In all cases the product remained under safe limits showing that toffees could be preserved for 180 days without any danger to human safety.

Table 4.29: Effect of Storage period & Storage temperature on micro-biological properties of honey chicory toffee

Storage period (Days)	parameters			
		TPC (log cfu/g)	Y&M count (log cfu/g)	Coli form count (log cfu/g)
0		ND	ND	ND
30	Room Temp.	ND	ND	ND
	Ref. Temp.	ND	ND	ND
60	Room Temp.	2.56±0.20	TFTC	ND
	Ref. Temp.	TFTC	TFTC	ND
90	Room Temp.	3.00±0.11	TFTC	ND
	Ref. Temp.	1.90±0.50	TFTC	ND
120	Room Temp.	3.79±0.05	3..42±0.06	ND
	Ref. Temp.	2.42±0.60	2.00±0.15	ND
150	Room Temp.	4.46±0.15	3.89±0.20	ND
	Ref. Temp.	2.85±0.50	2.02±0.50	ND
180	Room Temp.	4.96±0.15	4.02±0.20	ND
	Ref. Temp.	3.21±0.25	2.25±0.30	ND

* ND – Not Detected

** TFTC – Too few too count

4.5.6 Effect of storage temperature and storage period on organoleptic properties of honey skim milk toffee

The data on the organoleptic characteristics, presented in table 4.30 revealed that the colour, flavour, taste, texture and overall acceptability of honey toffees decreased gradually but significantly with increase in storage period of 180 days at ambient conditions. However, the temperature of storage significantly affected all the organoleptic quality attributes of toffee. For example, the flavour did not change in refrigerated storage for 180 days and texture decreased marginally from score of 7.66±0.57 on 0^{th} day to 7.33±0.28 on 180^{th} day of storage in refrigerated condition. The score for colour was 8.00±0 on 0^{th} day and decreased up to 7.66±0.57 only on 180^{th} day though during 90 days refrigerated storage there was no effect on this quality. Similarly the score for taste also decreased slightly form 8.66±0.57 on 0^{th} day to 8.00±0 on 180^{th} day. Form overall acceptability point of view; there was an insignificant decrease of organoleptic qualities during 180^{th} day of storage. The score decreased from initial value of 8.00±0 to 7.66±0.19 during 180^{th} days storage at refrigerated condition. Tables 4.30. (a to e) show the results of ANOVA for colour, flavour, taste, texture and overall acceptability.

Table 4.30: Effect of Storage period & Storage temperature on organoleptic properties of honey toffee

Parameters	0 days	After 90 days Storage at		After 180 days Storage at	
		Room Temp.	Ref. Temp	Room Temp.	Ref. Temp
Colour	8.00±0	7.33±0.57	8.00±0.0	6.00±0.0	7.66±0.57
Flavour	7.66±0.57	7.33±0.57	7.66±0.57	6.33±0.57	7.66±0.57
Taste	8.66±0.57	7.00±0.0	8.33±0.57	5.83±0.28	8.00±0.0
Texture	7.66±0.57	6.33±0.57	7.56±0.51	6.16±0.28	7.50±0.50
O.A.*	8.00±0.0	7.00±0.25	7.89±0.12	6.08±0.26	7.70±0.26

OA* Overall Acceptability

Table 4.30(a): ANOVA for Colour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0010111	0.0005056			
StorageTemp.(T)	1	2.4938889	2.4938889	354.3015	4.96	10.04
Storage(S)	2	4.1613778	2.0806889	295.59905	4.1	7.56
TxS	2	1.8365778	0.9182889	130.45935	4.1	7.56
Error	10	0.0703889	0.0070389			
Total	17	8.5632444				

CD 5% **CD 1%**

T = 0.0881173 T = 0.1253338

S = 0.1079212 S = 0.1535019

Table 4.30(b): ANOVA for Flavour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0358333	0.0179167			
Storage Temp.(T)	1	1.3833389	1.3833389	195.47888	4.96	10.04
Storage(S)	2	1.3796333	0.6898167	97.477626	4.1	7.56
TxS	2	1.4770778	0.7385389	104.36254	4.1	7.56
Error	10	0.0707667	0.0070767			
Total	17	4.34665				

CD 5% **CD 1%**

T = 0.0883534 T = 0.1256696

S = 0.1082104 S = 0.1539132

Table 4.30(c): ANOVA for Taste

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0175	0.00875			
Storage Temp.(T)	1	6.3605556	6.3605556	1042.1445	4.96	10.04
Storage(S)	2	8.9425	4.47125	732.59148	4.1	7.56
TxS	2	3.6764111	1.8382056	301.18059	4.1	7.56
Error	10	0.0610333	0.0061033			
Total	17	19.058				

CD 5% **CD 1%**

T = 0.0820526 T = 0.1167077

S = 0.1004935 S = 0.1429372

Table 4.30(d): ANOVA for Texture

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0154111	0.0077056			
Storage Temp.(T)	1	2.4568056	2.4568056	588.8482	4.96	10.04
Storage(S)	2	3.1824778	1.5912389	381.38881	4.1	7.56
TxS	2	1.2704111	0.6352056	152.24634	4.1	7.56
Error	10	0.0417222	0.0041722			
Total	17	6.9668278				

CD 5%		CD 1%	
T =	0.0678411	T =	0.0964939
S =	0.083088	S =	0.1181804

Table 4.30(e): ANOVA for Overall Acceptability

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0104111	0.0052056			
Storage Temp.(T)	1	2.7926722	2.7926722	3017.2929	4.96	10.04
Storage(S)	2	3.7748778	1.8874389	2039.2497	4.1	7.56
TxS	2	1.7887444	0.8943722	966.30852	4.1	7.56
Error	10	0.0092556	0.0009256			
Total	17	8.3759611				

CD 5%		CD 1%	
T =	0.0319529	T =	0.0454483
S =	0.0391341	S =	0.0556625

4.5.6 Effect of storage temperature and storage period on organoleptic properties of honey skim milk chicory toffee

The data on the organoleptic characteristics, presented in table 4.31 revealed that the colour, flavour, taste, texture and overall acceptability of honey based chicory toffees decreased gradually but significantly with increase in storage period of 180 days at ambient conditions. However, the temperature of storage significantly affected all the organoleptic quality attributes of toffee. The change pattern in all these characteristics during 180 days storage was similar as stated in case of honey toffee.

Table 4.31: Effect of Storage period & Storage temperature on organoleptic properties of honey Chicory toffee

Parameters	0 days	After 90 days Storage at		After 180 days Storage at	
		Room Temp.	Ref. Temp	Room Temp.	Ref. Temp
Colour	7.66±0.11	7.00±0.14	7.50±0.50	6.75±0.10	7.50±0.05
Flavour	8.12±0.10	7.66±0.11	8.00±0.0	6.90±0.57	8.00±0.25
Taste	8.86±0.05	7.00±0.40	8.00±0.50	6.20±0.15	8.00±0.14
Texture	7.36±0.06	6.55±0.10	7.33±0.25	6.00±0.05	7.33±0.20
O.A.*	8.00±0.02	7.06±0.06	7.71±0.07	6.48±0.56	7.71±0.07

OA* Overall Acceptability

Table 4.31(a): ANOVA for Colour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0208444	0.0104222			
Pckg. Sys(P)	1	0.7401389	0.7401389	85.05171093	4.96	10.04
Storage(S)	2	0.9220111	0.4610056	52.97561287	4.1	7.56
PxS	2	0.4302778	0.2151389	24.72229316	4.1	7.56
Error	10	0.0870222	0.0087022			
Total	17	2.2002944				

CD 5% **CD 1%**

P= 0.097977 P= 0.1393577

S= 0.1199968 S= 0.1706777

Table 4.31(b): ANOVA for Flavour

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0012333	0.0006167			
Pckg. Sys(P)	1	1.0320056	1.0320056	80.02110795	4.96	10.04
Storage(S)	2	1.3682333	0.6841167	53.04600672	4.1	7.56
PxS	2	0.9530111	0.4765056	36.94796244	4.1	7.56
Error	10	0.1289667	0.0128967			
Total	17	3.48345				

CD 5% **CD 1%**

P= 0.1192745 P= 0.1696503

S= 0.1460809 S= 0.2077784

Table 4.31(c): ANOVA for Taste

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0361444	0.0180722			
Pckg. Sys(P)	1	3.9668056	3.9668056	1142.44	4.96	10.04
Storage(S)	2	9.8365444	4.9182722	1416.4624	4.1	7.56
PxS	2	2.4052778	1.2026389	346.36	4.1	7.56
Error	10	0.0347222	0.0034722			
Total	17	16.279494				

CD 5% **CD 1%**

P= 0.0618889 P= 0.0880278

S= 0.0757981 S= 0.1078116

Table 4.31(d): ANOVA for Texture

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0168778	0.0084389			
Pckg. Sys(P)	1	2.1701389	2.1701389	461.1865407	4.96	10.04
Storage(S)	2	1.4286111	0.7143056	151.8004723	4.1	7.56
PxS	2	1.2852778	0.6426389	136.5702479	4.1	7.56
Error	10	0.0470556	0.0047056			
Total	17	4.9479611				

CD 5%		CD 1%	
P=	0.0720467	P=	0.1024758
S=	0.0882389	S=	0.1255067

Table 4.31(e): ANOVA for Overall Acceptability

Source	df	SS	MSS	F- Value (cal)	F Table5%	F Table1%
Repl.	2	0.0029778	0.0014889			
Pckg. Sys(P)	1	1.78605	1.78605	427.0576514	4.96	10.04
Storage(S)	2	2.5605444	1.2802722	306.1224761	4.1	7.56
PxS	2	1.1482333	0.5741167	137.2755048	4.1	7.56
Error	10	0.0418222	0.0041822			
Total	17	5.5396278				

CD 5%		CD 1%	
P=	0.0679223	P=	0.0966094
S=	0.0831875	S=	0.1183219

4.5.7 Comparison of Honey Toffees with selected fruit toffees

4.5.7.1 Comparison with Papaya toffee

Diwate et.al, (2004) have developed papaya toffee using papaya pulp as raw material along with sugar (750g/kg), skim milk powder (50g/kg), hydrogenated fat (80g/kg), salt (5g/kg), citric acid (2g/kg) and gum (5g/kg pulp). The toffees were packed in butter paper and wrapped with metallic coated polyethylene wrapper before final packaging in 150 gauge plastic bag. These toffees exhibited a shelf life of over 90 days at ambient conditions of storage. The fresh toffees had 9.07% moisture content, 82.80°Brix TSS, 0.34% titrable acidity, 28.33% reducing sugars, 69.88% total sugars and 9.35mg/100g β-carotene. The moisture content and β-carotene content decreased upto 8.1% during 90 days storage but TSS, reducing sugars and total sugars slightly increased during storage. The toffees scored 8.3 on 9 point scale for overall acceptability which decreased gradually upto 7.63, 7.31 and 6.94 respectively after 30, 60 and 90 days storage. These results showed that papaya based toffees suffered from loss in colour, texture and flavour during storage.

In comparison to this papaya toffee, the fresh honey toffee had moisture content value of 7.83%, fat content of 14.6%, reducing sugar content of 27.99% and total sugar content of 67.43%. The corresponding values for these properties for honey chicory toffees were respectively 9.10%, 15.40%, 29.43% and 69%. The fresh honey toffee scored 8 on 9 point hedonic scale for overall acceptability, which decreased upto 7 and 7.89 after 90 days storage at room temperature and refrigerated storage respectively. These values further reduced upto 6 and 7.7 respectively after

180 days storage. The honey toffee and honey chicory toffee both suffered from loss in colour, taste and texture and physico-chemical characteristics but remained acceptable to panelists.

4.5.8 Effect of storage period and storage temperature on textural characteristic of honey skim milk toffee and honey skim milk chicory toffee

Textural profile analysis test was conducted on texture analyzer to evaluate the textural property of honey toffee and honey chicory toffee, which indicated the force required to cause rupture the sample. The tests were carried out for all the samples, from fresh level to 6 month of storage and are presented in Table 4.32

Hardness of all the honey and honey chicory toffee was decreased during storage. The hardness value of honey toffee was higher as compared to honey chicory toffee. The value of hardness of honey toffee was 17718.3g while honey chicory toffee value 15677.2g. The continuously decreased trend was observed during 6 months of storage and same trend was observed in honey chicory toffee. Stickiness of fresh honey toffee was lower but after three month storage at ambient temperature it was higher, further this value is continuously decreasing during storage period. The stickiness of fresh honey chicory toffee was higher as compared to storage period and decreasing trend was observed during upto 6 months of storage.The reason for

Table 4.32: Effect of storage period and storage temperature on textural characteristic of honey toffee and honey chicory toffee

Sample		Hardness g (+Ve)	Stickiness g (-Ve)
Fresh Honey Toffee		17718.3 g.	- 817.8 g
3 Month Storage	HT1	6668.8 g.	-3116.0 g.
	HT2	2816.6 g	- 2189.6 g.
6 Month Storage	HT1	1183.6 g.	- 1122.6 g.
	HT2	878.1 g.	- 749.7 g.
Fresh Honey Chicory Toffee		15677.2 g.	-3994.0 g.
3 Month Storage	HT1	1684.2 g.	- 1395.4 g
	HT2	793.4 g.	- 617.4 g.
6 Month Storage	HT1	637.9 g.	- 571.2 g.
	HT2	515.9 g.	- 437.4 g.

HT1= Honey Toffee at Ambient Temperature, HT2= Honey Toffee at Refrigerated Temperature

decrease in hardness was evidently due to the increase in moisture content during storage resulting to softening of samples. Effects of storage on textural properties of different samples of honey toffee and honey chicory toffee are shown in Fig. 4.14 to 4.18 and Fig. 4.19 to 4.23 respectively.

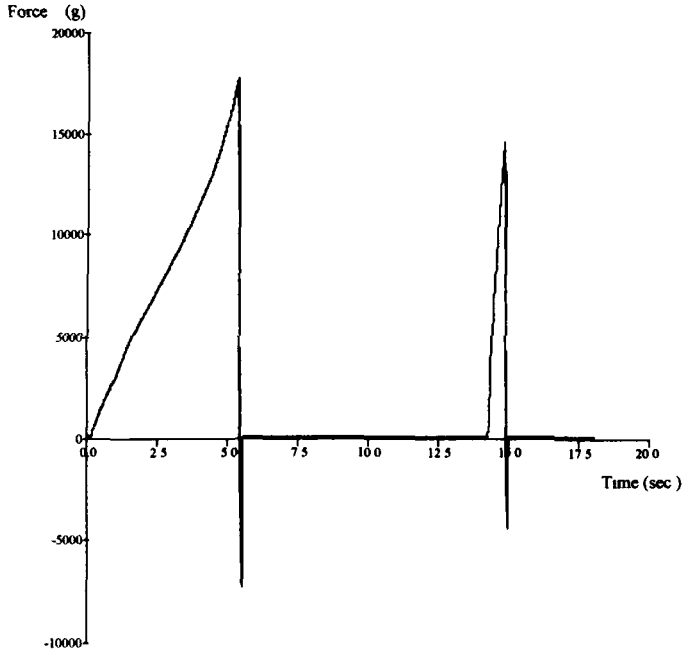


Fig. 4.14 Textural analysis of fresh honey toffee

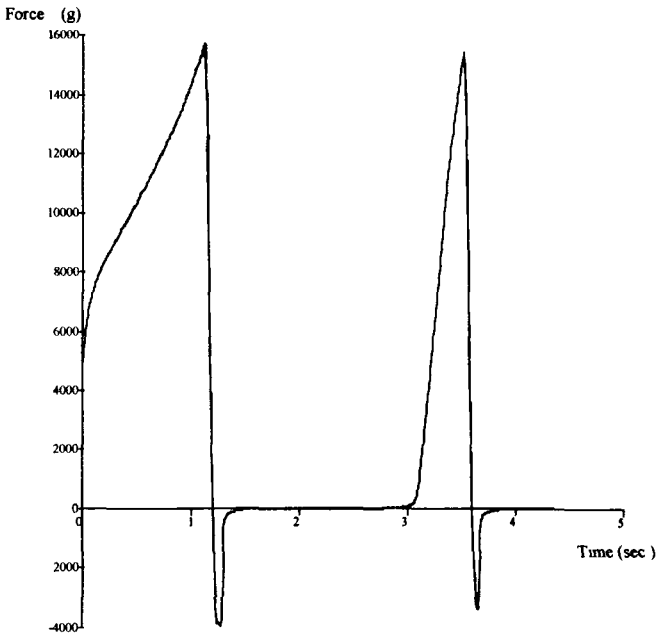


Fig. 4.15 Textural analysis of honey toffee stored at refrigerated temperature after 3 months

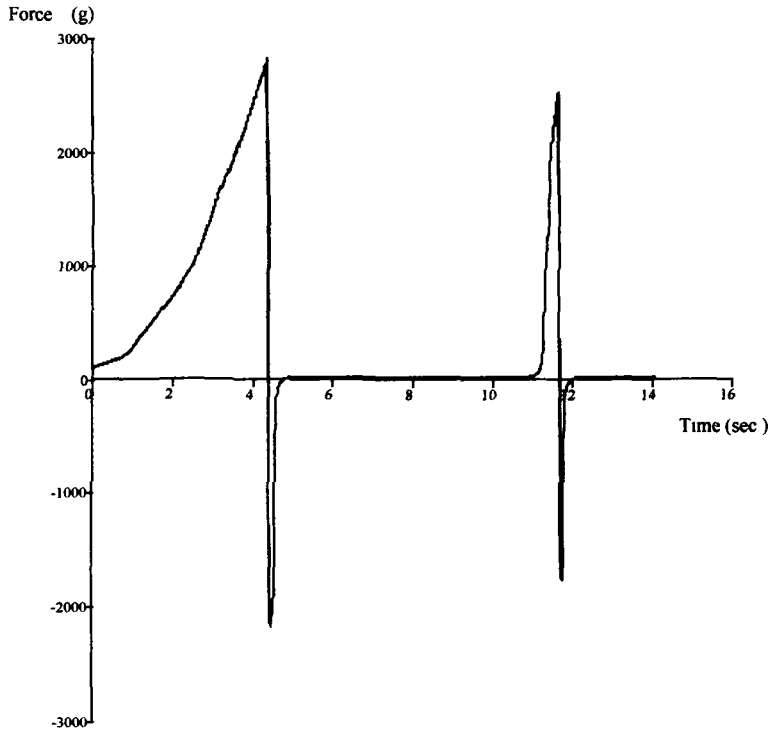


Fig. 4.16 Textural analysis of honey toffee stored at ambient temperature after 3 months

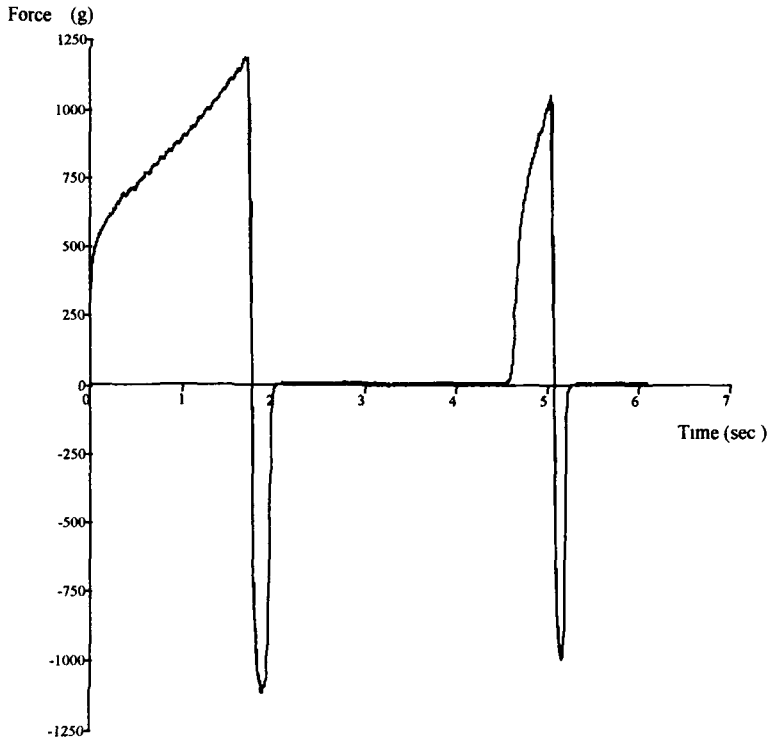


Fig. 4.17 Textural analysis of honey toffee stored at refrigerated temperature after 6 months

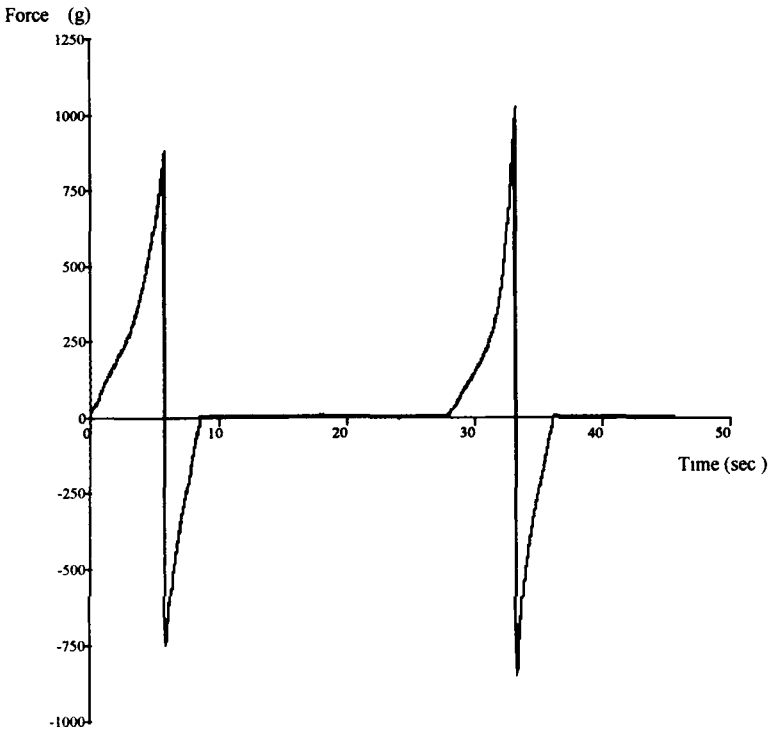


Fig. 4.18 Textural analysis of honey toffee stored at ambient temperature after 6 months

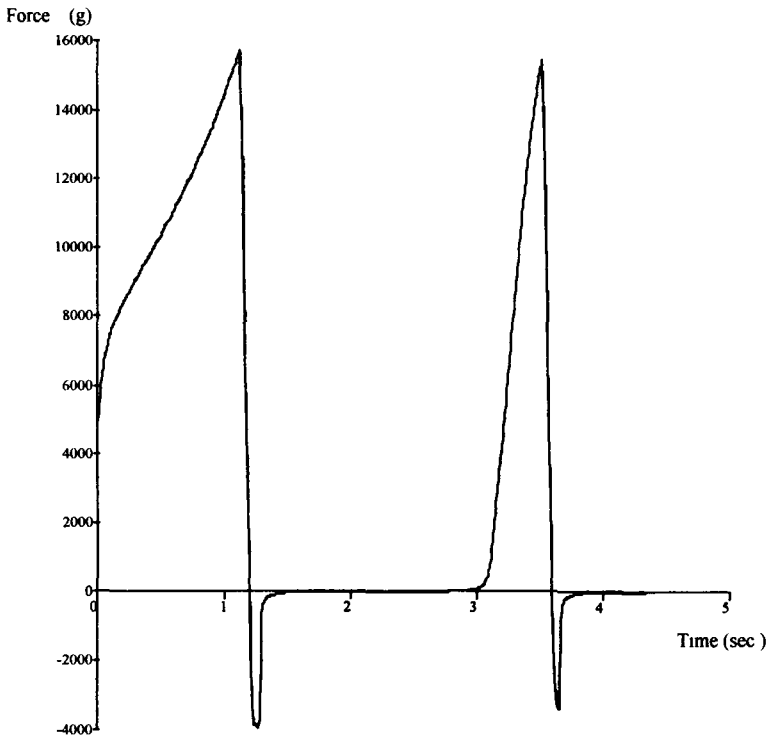


Fig. 4.19 Textural analysis of fresh honey chicory toffee

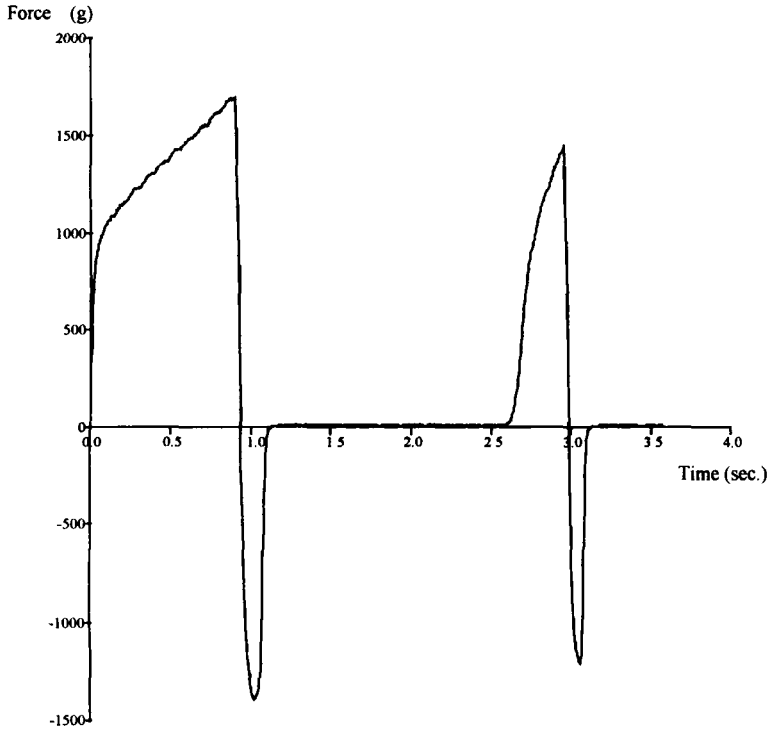


Fig. 4.20 Textural analysis of honey chicory toffee stored at refrigerated temperature after 3 months

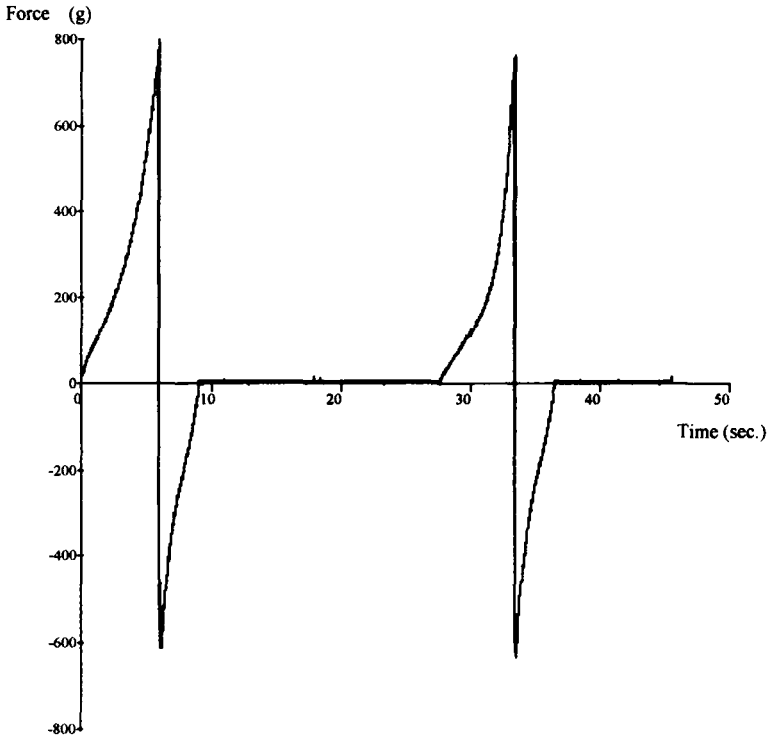


Fig. 4.21 Textural analysis of honey chicory toffee stored at ambient temperature after 3 months

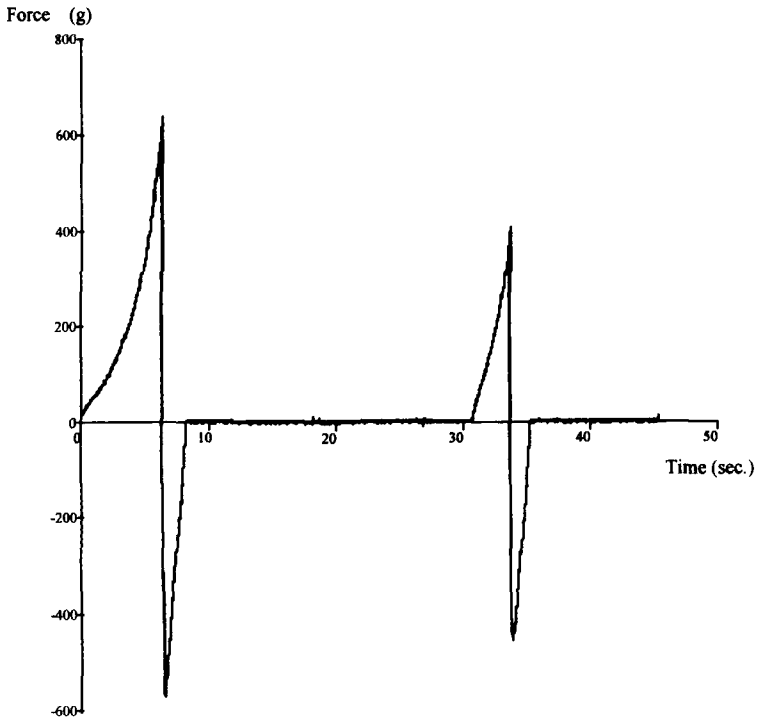


Fig. 4.22 Textural analysis of honey chicory toffee stored at refrigerated temperature after 6 months

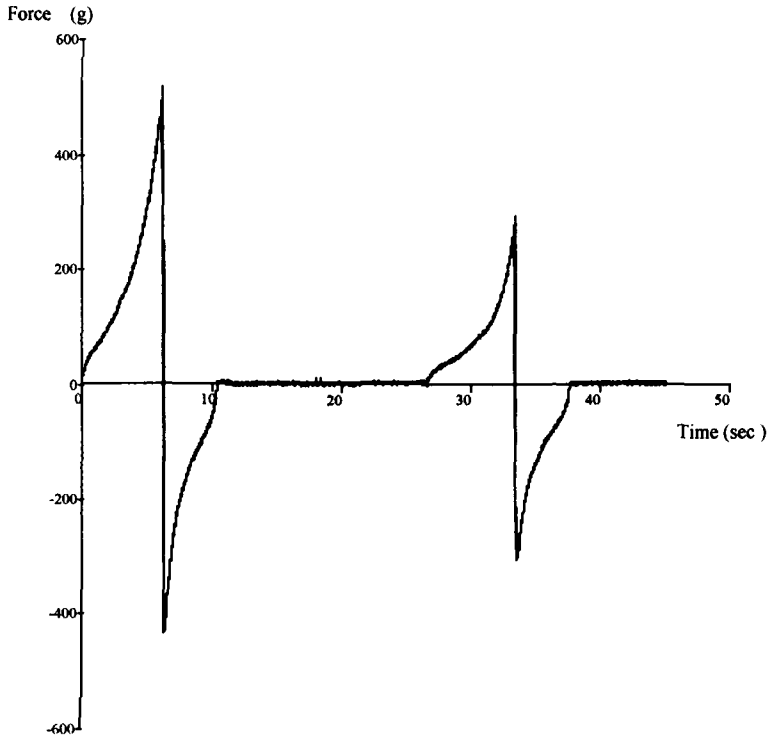


Fig. 4.23 Textural analysis of honey chicory toffee stored at ambient temperature after 6 months

4.5.9 Economic Analysis:

On the basis of results of the study, a combination of 40% of skim milk powder, 65.78% honey and 12% hydrogenated fat was found the best among all treatments for production of best quality of honey based milk toffees. Similarly addition of 3% roasted chicory powder in above formulation resulted in development of nutritionally higher quality toffees. Therefore, for economic analysis of honey based toffees manufacturing at small scale, the above described composition was selected with following rational assumptions:

Assumptions

- Production target = 10 kg /hr, 80 kg / day or 24, 000 kg / y
  = or 24 t / year of 300 working days.
- Equipment & utensils required

(i) Toffee moulding machine = Rs. 65, 000

(ii) Utensils = Rs. 5, 000

- Electrical fittings = Rs. 1, 000

Sub Total = Rs. 71, 000

- Life of toffee moulding machine & other utensils = 10 years
- Cost of annual repair & maintenance = 5 % of initial cost
- Annual rate of interest on investment = 15 % of initial cost
- Labour requirement = One skilled and two unskilled @ Rs.150 /d/person and Rs. 75/d/person respectively
- Working hours and days / year = 8 h /day, 300 days / year
- Working Capital = Variable cost for 25 days per month
- Sale price of toffee = Rs. 120 / kg

Raw materials requirement, kg/h

(i) Honey @ Rs. 75 /kg = Rs. 493.50 /hr

(ii) Milk powder @ Rs. 150 / kg = Rs. 394.50 /hr

(iii) Hydrogenated fat @ Rs. 46/kg = Rs. 36.00 /hr

Total = Rs. 924.00 /hr

- Cost of packaging material
  - (i) Primary packaging @ 500 Rs. /kg = Rs. 4,000
  - (ii) Secondary packaging = Rs. 3,600

  Total = Rs. 7,600
- Cost of cooking gas (LPG) cylinder = Rs. 400/cylinder of 14.5 kg
- No. of cooking gas cylinder required /m = 2.
- Main product recovery = 100%
- Electric power consumption @ Rs 3/kwh (unit) = 40 units/day for operation of moulding machine
- Rent of building (20'X20') = Rs. 1000/ month

Calculations:

- **Working Capital requirement, Rs / month of 25 days**

= Cost of raw materials/month + Labour charges for 25 days + Rent of housing for 30 days + Electricity charges for 30 days + Requirement of cooking gas for 25days + Cost of packaging material for 25 days production

= Rs. (924 /h X 8 X25) + Rs. (300 X25) + Rs. 1000 + Rs. (40X25X3) + Rs. (400X2) + Rs. 634

= Rs.184800 + Rs.7500 + Rs.1000 + Rs.3000 + Rs.800 + Rs.634

= Rs.1, 97,734 / —

- **Annual Fixed Costs Rs.**

= Depreciation + interest on fixed capital + maintenance + rent/ housing cost + Interest on working capital for the period of operation

$$= \frac{Rs.(71,000\ \ 7,100)}{10} + + Rs\,(0.15\,X\,71,000) + Rs.(0.05\,X\,71,000)$$

$$+ Rs.(1000\,X12) + \frac{Rs.(0.15\,X\,1,97,734\,X\,300)}{365}$$

= Rs. (6,390 + 10,650 + 3.550 + 12,000 +24378.16)

= Rs. 53421.71 **say Rs. 53422 / —**

- **Capital investment**

= Initial cost of equipment + 30% of working capital

= Rs. (71,000) + (0.3 X1, 97, 734)

= Rs. (71,000 + 59320.2)

= Rs. 1, 30,320.2 **say Rs. 1, 30,320 / —**

- **Hourly variable cost**

= Rs. (300/8) + Rs.924 + Rs. (192 / 8 X6) + Rs. (120/ 8) + Rs. (152/8) + 0.05 X all previous charges

= Rs. 37.5 + Rs. 924 +Rs. 4.0 + Rs.15 + Rs. 19 + 0.05 X 999.50

= Rs. (999.50 + 49.97) = Rs. 1049.47 **say Rs. 1050 / —**

- **Annual variable cost**

= Hourly variable cost X No. of operation hrs / year

= Rs. 1050 X 8 X300

= **Rs. 25, 20,000 / —**

- **Total Annual cost**

= Annual (fixed + variable) costs

= Rs. (53,422 +25, 20,000)

= Rs. 25, 73,422 / —

- **Cost of operation, Rs/hr.**

$$= \frac{\text{Total annual costs}}{\text{operation hrs/year}}$$

$$= \frac{25,\ 73,422}{8 \text{ X } 300} = \text{Rs.}1072.25 \text{ /hr } \textbf{say Rs. 1073 /hr}$$

- **Cost of processing, Rs/kg**

$$= \frac{\text{Hourly cost of processing}}{\text{Capacity per hour}}$$

$$= \frac{\text{Rs. 1073}}{10} = \text{Rs, 107.3 } \textbf{say Rs. 108/kg}$$

- **Annual sales revenue**

= Sale price / kg X Total Production

= 120 X 10 kg/hr X 8 hrs./ day X 300 days/year

= Rs. 28, 80,000/ year

- **Annual net profit**

= Annual sales revenue – total annual cost

= Rs. (28, 80,000 – 25, 73, 422)

= Rs. 3, 06, 578 / —

- **Break even point (BEP)**

(a) In terms of no. of operation hrs /year

Let BEP occurs at x hours of operation /year

At this stage,	total costs	=	total revenues
i.e. Fixed cost + hourly variable cost X x		=	per hr. sale revenue X x
Rs. 53,422 + Rs. 1050 X x		=	120 X 10 X x
Rs. 53,422 + Rs. 1050 x		=	1200 x
so	x	=	53,422 / 150 = 356.14 hrs.
		=	say Rs. 356 hrs.

(b) In terms of quantity handled

= x X capacity per hr.

= 356 X 10 kg /hr = **3560 kg/year**

- **Pay back period**

$$= \frac{\text{Capital investment}}{\text{Net profit Rs./y + Depreciation}}$$

$$= \frac{1,30,320}{3,06,578 + 7,100}$$

$$= \textbf{0.41 years}$$

- **Return – on – investment**

$$= \frac{\text{Net profit, Rs/y}}{\text{Capital investment, Rs}} \times 100$$

$$= \frac{\text{Rs } 3,06,578}{\text{Rs } 1,30,320} \times 100$$

$$= \textbf{227.5 \%}$$

Above economic analysis and economic indicators suggest that manufacturing of honey based milk toffees on small scale has good economic viability.

Chapter-5

Summary and Conclusion

It is well known fact that white sugar contains very high amount of sucrose and is an extremely poor food. The excessive consumption of sucrose quite often leads to variety of health problems, which can be avoided by replacing white sugar with natural sweeteners like honey. Honey is a complex mixture of carbohydrates, several enzymes, amino acids, organic acids, minerals, aroma substances, pigments etc. In comparison to white sugar, honey contains large amounts of fructose and glucose. Honey also has anti microbial, antifungal, anti oxidant properties besides several medicinal properties.

Like honey, the fruits and vegetables used in this study also have therapeutic value and uses. Aonla fruit is highly nutritive and it is richest source of vitamin C. fruits are also utilized for making the Ayurvedic medicines such as chavanprash, Trifla, Amla ki Rasayan and powder, which are good for the diabetic patients. Guava is a rich source of ascorbic acid and pectin. High quality necter can be prepared from guava (Baramanry et.al, 1951). Papaya is very wholesome fruit. Aykroyed (1995) ranks it second only to mango as a source of the precursor of vitamin A. They are used in preparation of jam, soft drinks, icecreams flavouring and crystallized fruits in syrup. At last, carrot is valued as food mainly because it is a rich source of ά and β- carotene. Carrot roots are used as vegetable for soups, stews and used as salad. Carrot juice is a rich source of carotene and carrots are also canned.

In the present study honey was used as natural sweetener in place of white sugar for the preparation of various types of food products namely candy, murabba, squash, jam and toffee. Product wise recipes were finalized by determining optimal quantities of honey to be used. All the above named product were evaluated for various physico-chemical, microbial, textural (where ever required) and organoleptic characteristics in fresh (on 0^{th} day of storage) as well as during six months storage at different intervals. For shelf life studies different packaging materials and storage conditions were used. Statistical and economic analysis was worked out for all above products separately to encourage small scale entrepreneurs. Results obtained on the basis of this study the most suitable conclusion are presented product wise:

1. Honey carrot candy

(i) It was observed that very good quality carrot candy can be prepared by mixing 750 g of honey per kg of carrot.

(ii) It was also observed that fresh honey carrot candy contains 28% moisture content, 72°Brix TSS, 0.064% acidity, 0.02 browning index, 30.5% reducing sugar, 78% total sugars, 16.27mg per 100gm Beta carotene content.

(iii) The fresh carrot candy scored 8.33 on 9 point hedonic scale with respect to overall acceptability which decreased up to 6.83 and 6.79 respectively in glass jar and LDPE pouch during 180 days storage at ambient condition. This score corresponded to rated between 'liked moderately' to 'liked slightly'.

(iii) Honey carrot candy was found at par in various organoleptic characteristics with carrot candy prepared in sugar and jaggery syrup.

(iv) In comparison to intermediate moisture (IM) carrot preserved, the honey carrot candy scored higher for organoleplitc characteristics. Similarly in comparison to carrot milk cake the honey carrot candy was found to be at par with respect to organoleptic qualities.

(v) Small scale industry can be established for production of honey carrot candy with production target 10kg/hr. The cost of production of honey carrot candy worked out to be Rs 52/kg. The annual net profit of Rs 2, 83,764 can be obtained with a return on investment 563% of the product is sold at the rate of Rs 75/kg.

2. Honey aonla murabba

(i) It was observed that honey aonla murabba can be prepared by mixing honey and aonla in 1:1ratio. The score for organoleptic characteristic for such product on 9 point hedonic scale were respectively 7.85 for colour, 8.05 for flavour, 7.95 for juiciness, 8.05 for texture and taste and 7.99 for overall acceptability.

(ii) It was also observed that the fresh honey aonla murabba contained 48.33% moisture content, 52.5°Brix TSS, 6.88% acidity, 0.037 browning index, 27.3% reducing sugars, 50.4% total sugar, 152.1mg/100gm vitamin C.

(ii) The physico-chemical composition and microbial characterstics were respectively found to be decreasing and increasing during 180 days storage at ambient conditions when packed in glass jar and PET jars. However, with respect to microbial characteristics glass jar proved to be a better packaging material with TPC, Y & M

count being in safe limits. During 180 days storage no coliform count could be detected.

(iii) After 180 days storage the score for colour, flavour, juiciness, texture, taste and overall acceptability were respectively 7.15, 7.10, 7.77, 7.52, 6.98 and 7.31 in glass jar and between 7.37 to 6.75 for these characteristics in PET jar showing that the product was rated between 'liked moderately' to 'liked slightly' after 180 days of storage. However with respect to taste the product was rated between 'liked very much' to 'liked moderately'.

(iv) In comparison to sugar syrup segments of aonla, the fresh honey aonla murabba had higher vitamin C content.

(v) A small industry can be set up for production of honey aonla murabba with the investment of Rs 48,442. With a production target of about 18kg/hr, the cost of processing worked out to be Rs 45/kg and with a sell price of Rs 75/kg. The net annual profit works to be Rs 2,63,702 with return on investment of 545%.

3. Honey Aonla Squash

(i) It was observed that honey aonla squash can be prepared by mixing 60% of aonla juice and 40% of honey.

(ii) It was also observed that fresh honey aonla squash had 35.0°Brix TSS, 0.4% acidity, 0.08 browning index , 23.7% reducing sugar, 45.5% total sugar and 78.6% vitamin C content.

(iii) The scores for organoleptic characteristic for such product on 9 point hedonic scale were respectively 7.66 for colour, 7.66 for flavour, 8.66 for taste and 8.00 for overall acceptability. This score decreased gradually during 180 days storage. The overall acceptability scores remained 6.20 and 7.05 respectively at ambient and refrigerated temperatures. This score corresponded to rated between 'liked moderately' to 'liked slightly'.

(iv) In comparison to aonla syrup the honey aonla squash has very high scores for all organoleptic characteristics. The ascorbic acid content is higher (78.6mg/100g) in honey aonla squash as compared to aonla squash (51.1mg/100g) prepared with sugar.

(v) The microbial counts were found to be increasing during 180 days of storage at room temperature and refrigerated temperature. However with respect to microbial characteristics refrigerated storage was better as compared to storage at room

temperature with TPC, yeast and mould being in safe limits. No coli form count was detected during 180 days storage.

(vi) Small scale industry can be established for production of honey aonla squash with production target 10 lt/hr. A cost of production of honey aonla squash worked out to be Rs 56/lt and with a sell price of Rs 75/kg. The annual net profit of Rs 1, 11,052 can be obtained with a return on investment of 266%.

4. Honey mixed fruit jam

(i) It was observed that honey mixed fruit jam can be prepared by mixing 750g of honey per kg of mixed fruit pulp. The score for organoleptic characteristic for such product on 9 point hedonic scale were respectively 8.78 for colour, 8.06 for flavour, 7.63 for texture, 8.57 for taste and 8.26 for overall acceptability.

(ii) It was also observed that the fresh honey mixed fruit jam contained 48.33% moisture content, 52.5°Brix TSS, 6.88% acidity, 0.037 browning index, 27.3% reducing sugars, 50.4% total sugar, 152.1mg/100gm vitamin C.

(iii) The microbial counts were found to be increasing during 180 days of storage at room temperature and refrigerated temperature. However with respect to microbial characteristics refrigerated storage was better as compared to storage at room temperature with TPC, yeast and mould being in safe limits. No coli form count was detected during 180 days storage.

(vi) Small scale industry can be established for production of honey mixed fruit jam with production target 10kg/hr. The cost of production of honey mixed fruit jam worked out to be Rs 77/kg. The annual net profit of Rs 2, 27,072 can be obtained with a return on investment 118% of the product is sold at the rate of Rs 105/kg.

5. Honey toffee

(i) It was observed that honey toffee can be prepared by mixing 400g milk powder, 120g hydrogenated fat/kg of honey.

(ii) It was also observed that Fresh honey toffee contains 7.83% moisture content, 6.50 pH, 14.6% fat content,0.25 browning index, 27.99% reducing sugar and 67.43% total sugar.

(iii) The fresh honey toffee scored 8.00 on 9 point hedonic scale with respect to overall acceptability which decreased up to 6.08 and 7.50 respectively at room temperature and refrigerated temperature during 180 days storage. This score corresponded to rated between 'liked moderately' to 'liked slightly'.

(iv) Honey toffee was found at par in various organoleptic characteristics with papaya toffees.

(v) The microbial characteristics were found to be increasing during 180 days of storage at room temperature and refrigerated temperature. However with respect to microbial characteristics refrigerated storage was better as compared to storage at room temperature with TPC, yeast and mould being in safe limits. No coliform count was detected during 180 days storage.

(vi) A small industry can be set up for production of honey toffee with the investment of Rs. 1, 30,320 with a production target of 10kg/hr. The cost of processing works out to be Rs 108/kg and with a sell price of Rs 120/kg. the net annual profit of Rs 3,06,578 can be obtained with a return on investment of 227.5%.

Recommendations

(i) Out of five different types of products developed in this study, Honey Carrot Candy, Honey Aonla Murabba, and Honey Toffee have found greater response from a large section of society who were served these products. Similar other products from other fruits and vegetables may be developed and evaluated.

(ii) The technologies developed in this project may be transferred to entrepreneurs for large and small scale adoptions particularly in rural areas.

(iii) Media needs to be informed about the potential use of honey in various foods. So that mass awareness of people can be created about the antimicrobial, antifungul, antioxidant and medicinal properties.

(iv) As the fruits and vegetables used in this study have therapeutic value and uses. The product developed by this study can be taken on clinical trail for combating various specific nutritional deficiencies.

(v) The products developed in this study if properly incorporated, may lead to income generation to control poverty level and helps in overall National development.

(vi) Studies related to packaging of different products apart from method used in this study needs to be carried out in future.

(vii) Possibility of incorporation of honey in place of white sugar in development of other sweet products needs further R and D studies.

Chapter- 6

Bibliography

Andujar BP (1974) Honey is baby's nutrition. In: The hive products: food, health and beauty (V.Harnaj, ed). Proc. Apitherapy; Madrid, Spain, Apimondia, pp 69-70.

Anonymous (1952) Wealth of Indian-Raw materials. Vol. 3, CSIR, New Delhi.

Anonyms (2002) shahad Takanik, MP Vigyan Sabha, Bhopal.

Arenas De Moreno, L Mann M, Castro De Rincon C and Sandoval L (1995) revista de la Facultad de Agronomia, Universidad del Zulia, 12 : 467-483.

Asenjo CF (1953) Bull. De colegio de Quimicos de, Puerto rico 10 : 8-17.

Aykroyd WR (1951) The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets, Govt. of India Res. New Delhi.

Badillo VM (1917) Monografia de la familia Caricaceae. Maracay, Venezuela.

Bajpai PN (1963) Ph.D thesis submitted to Agra University, Agra

Baramanray A, Gupta OP and Dhawan SS (1995) Haryana J. Hort. Sci., 24: 102-109.

Bardiya MC, Kundy BS and Tauro P (1974) Haryana J. Hort Sci 3:140.

Belitz HD and Groosch W (1999) Food Chemistry, Chapter 19. Page No. 821-828

Berthold R, Jr and Benton AW (1968) Creamed honey-fruit spreads. Food Techno, 22(1): 83.

Bhajekar DV and Kulkarni PR (1991) Osmotolerant Yeast isolated from fruit preserves. Nahrung, 35 (1): 99.

Bhupinder K, Gursharan K, Mankaran S, Kamalpreet K and Bhatti NK (2003) Honey: Gift of God Indian Farmer's Digest 36(7-8) 48-51.

Bhupinder K, Tejinder S, Gursharan K, Mankaran S, Kamalpreet K and Navdeep K, Bhatti (2004) Processing, Handling and Utilization of Honey, Processed Food Industry, vol. 7(6): 26-27, 34-35.

Billerback FW, Everett LH, Nc. Gowan PG and Pettinga PV (1976) sweetened storage stable peanut bultis spread and method or manufacture. U.S. Patent, 4000322.

Bose T K, Som M G and Kabir J (1993) Vegetable Crops in India, Naya Prakash, 206, Bidhan Sarani, Calcutta. .

Bose TK, Mitra SK and Sanyal D (Jan.2002) Fruits : Tropical and Subtrropical,

Burkill IH (1935) A Dictionary of the Economic Products of the Malay Peninsula.Vol. 1, Crown Agents for the Colonies, London.

Candert P (1971) Making long life bread. West German, Patent Appl, 2 (012511)

Ceyhan N and Uger A (2002) Microbial quality of some Turkish Honeys. J Fd. Sc. & Technol. 39(1): 62-65.

Chan HT and Kwok SCM (1975) J. Food Sci 40: 419.

Chauneja PK (2002) Honey Processing and Quality misconceptions and scientific facts, A paper Presente in 36th ISAE convention held at IIT Kharagpur Jan. 28-30.

Chopra RN (1933) Indigenous Drugs of India, The Art Press, Calcutta.

Chopra RN, Chopra IC, Handa KL and Kapur LD (1958) Chopra's Indigenous Drugs of India (2nd ed.), U. N. Dhur and Sons Pvt. Ltd., Calcutta.

Cioca V (1974) Use of pollen extract in cosmetics. In: The hive products: food, health and beauty. (V .Harnaj, ed). Proc. Apitherapy; Madrid, Spain, Apimondia 63-64.

Cohen EH J (1971) Assoc. Offic. Anal. Chem., 54, 212.

Colangelo K (1980) Combo packed yoghurt and granola gives convenience a healthy image. Diary field, 163(10): 95.

Cortopassi-Laurino M and Gelli DS (1991) Pollen analysis, physico-chemical properties and antibacterial activity of Brazilian honey from Africanised honey bees (*Apis mellifera*) and stingless bees. Apidologie 22, 61-73.

Crane E (1996) The past and present importance of bee products to man. In: Bee Products; Properties, Application and Apitherapy (Mizrahi and Lensky, eds.), Plenum Press, New York 1-13.

Das BC, Chakraborty A, Chakraborty PK, Maiti A, Mandal S and Ghosh S (1995) The Hort J 8 : 141-146.

Dold H, Du DH, Dziao ST (1937) Nachweis antibaketerieller hitze and licht emfindlicher hemmungs stoffe (inhibine) in Nature honey. 2. Hyg. Infektionskar 120: 155-167.

Dondel LW and Jaclesen SL (1980) Darkening effect of high iron honey on tea. Amer Bee J 120 (7): 516.

Fast RB, Hreschak BO and Spotts CE (1971) Honey-Graham Cereal, US Patent, 3554, 763.

Fayyaz A, Asbi BA, Ghazali HM, Man YBC and Jiap S (1994) Food Chem., 49: 373-378.

Firminger TA (1947) Firminger's manual of gardening for India, Thacker Spink Co. Ltd., Calcutta.

Floris I and Prota R (1989) The bitter honey of Sardinia. Apicoltore-Moderno, 80, 55-67.

Gajanana K, Rokhade AK, Patil PB and Kulkarni MS (2007) Standardisation of Recipe for preparation of Aonla squash. Beverage and Food World, March, 34 (3): 55-56.

Ghazali HM and Sin MK(1986) Coconut honey. The effect of storage temperature on some of its physico-chemical properties, J Apic Res 25,109.

Ghorai K (1991) studies on the quality improvement of Amla (Phyllanthus emblica L) Pickle. MSc. Thesis, Indian Agricultural Research Institute, New Delhi.

Ghosh SN and Chattapadhyay N (1996) The Hort J 9 : 121-127.

Glade Elmer F, Silver Brandt, Melvin H (1980) Effect of dextrin on breads with high molasses solids. Baker Dig, 54(3): 8.

Gopalan C, Rama Sastri BV and S.C. Balasubramanian (2004) Nutritive value of Indian Foods, NIN, ICMR, Hyderabad.

Gulati R and Kumari B (2005) Chemical Composition of Unifloral, stored and Commercial Apis mellifrera L. honeys. J. food Sci Technol, 42(6): 492-493.

Gupta GK and Bopaiah (1986) Indian Hort., 31:15.

Gupta JK, Kaushik R, Joshi VK (1992) Influence of different treatments, storage temperature and period on some physico-chemical characteristics and seasory qualities of Indian Honey, J Food Sci Technol 29(2): 84-87.

Gupta M, Bajwa U and Sandhu KS (2005) optimization of Variables associated with processing of carrot-milk cake. JFST. 42(1): 16-22.

Hanif M (1966) Pakistan J. Sci Res 18 : 61-63.

Harry W. von Loesecks (2001) Honey Out lines of Food Technology, PP 368-371

Hodge J (1953) Chemistry of browning reactions in model systems, J Agric fd Chem, 1, 928.

Hofmeyr JDJ (1938) Report Dept. of Agri. And Forestry, Union of South Africa.

Jain SK and Khurdiya (2002) Physico-chemical characteristics and post harvest technology of Aonla (Phyllanthus emblica lenn.) A Resume, Indian Food Packer, July-August.

Johnson BC (1948) Methods of Vitamin Determination, Burgess Publishing Co., Minnea polis, 98.

Kalman C (1974) Some medicinal properties of apiary products as an experience. In: The hive products: food, health and beauty. (V .Harnaj, ed). Proc. Apitherapy; Madrid, Spain, Apimondia, 114 – 118.

Kapanadze IS and Khasaya GS (1988) Subtropicheski Kultury, 1: 136-140.

Kaushik R, Joshi VK and Gupta JK (1993) Total soluble solids, acidity, pH and standard plate counts in the Indian honey as affected by different treatments and storage conditions. J. Food Sci. Technel 30: 442-443.

Kaye M. Russell's (1983) antibiotic qualities of NZ honeys, MSc thesis, Waikato University, New Zealand.

Keil U and Schreier P (1989) Phytochemistry, 28: 2281-2284.

Kirtikar K R and Basu B D (1935) Indian Medicinal Plants (Lolit Mohan Basu), Allahabad.

Koli SA, Kolekar TT, LS Kute and Chavan JK (2004) Preparation and storage of Sapota Jam. Beverage and Food World, December.20-21.

Kundu S, Ghosh SN and Mitra SK (1995) Indian Fd Packer 11-16.

Laftsidis S (1970) Dry honey and dry molasses. Bakers Digest 44(1): 70.

Lal G, Siddoppa GS and Tandon GL (1986) Preservation of Fruits and vegetables, ICAR Publication, New Delhi.

Lane JH and L Eynon (1923) J. Soc. Chem. Ind., 42, 32 T.

Lea CH and Hannan RS (1949) studies on the reaction between proteins and reducing sugars in the dry state. The effect of activity of water, pH and of temperature on the primary action between casein and glucose, Biochem Biophys Acta, 3, 313.

Lopez ME, Vattuone MA and sampietro AR (1988) Photochemistry, 27: 3077-3081.

Lothrop RE and Paine HS (1934) A new method for processing honey. American Bee, 74(12): 543-543.

Mackevic VI (1929) Bull. Appl. Bot. Genet Pl Breed 20 : 517-57.

Madan Shilpa and Dhawan SS (2005) Development of Value Added Product 'CANDY' from Carrots. Process Food Industry, January, 26-29.

Mandal RC and Nambiar PT N (2002) Agricultural, Statistics, Techniques and Procedure.

Manjunatha SS, Mohan kumar BL and Das Gupta DK (2003) Development and evaluation of carrot kheer mix. JFST 40(3): 310-312.

Mann JI (1987) Simple sugars and diabetes. Diabet Med; 4 (2): 135-39.

McLallan MR, Kime RW and Lind LR (1985) Apple juice clarification with honey and pectinase. J. Food Sci 50(1):206.

Mehta GL and Tomar MC (1979) Studies on the simplification of preserve making II Amla (Phyllanthus emblica L.) Ind. Fd. Packer 33(5): 27-30.

Methods of Vitamin Assay, The Association of Vitamin Chemists, Interscience Publishers New York, 3rd edn., p. 287 1966.

Mihailescu NN, Palos E, Volcinski T, Gorgas C (1974) Medicinal beverages of honey and natural substances. In: The hive products: food, health and beauty. (V .Harnaj, ed). Proc. Apitherapy; Madrid, Spain, Apimondia,

Mitra SK (1983) Ph. D. Thesis submitted to Bidhan Chandra Krishi Viswavidyalaya, Kalyani.

Molen PC (1992) The antibacterial activity of honey. 1. The nature of antibacterial activity. Bee World, 73:5-28.

Moraes MG De, Termignoni C and salas C (1994) Plant Sci. 102: 11-18.

Morton Julia F (1960) Econ. Bot 14: 119-128.

Mundo MA, Padilla - Zakour OI, Worobo RW (2004) Growth inhibition of foodborne pathogens and food spoilage organisms by select raw honeys. International Journal of Food Microbiology. in press.

Nadkarni AK (1927) Indian Materia Medica, S.K. Bijur, Bombay.

Naik AG and Chundawat BS (1993) In: Golden Jubilee Symp. Horticultural Reserch-changing scenario, Bangalore, Hert. Soc. India, May 24-28, Abst. No. 18.6, P.337.

Narinesingh D and Mohammed-Meraj R (1988) J. Sci. Food Agric., 46 : 175-186.

Nath V (1999) Delicacies of aonla. Ind. Hort., 44(3):15.

Ochse JJ (1931) Fruits and Fruit Culture in Ducth East Indies, G. Kolff and Co., Batavia.

Paine HS and Lothrop RE (1933) Influence of colloidal constituents on the development of colour in honey, Am Bu J, 73, 23.

Petrov V (1971) Qualitative determination of amino acids in some Australian honeys using paper chromatography, J Aphis Res 10, 153.

Pinera R, Hombre R De, Batista A and Cerezal P (1997) Alimentaria, 35: 19-20.

Premi BR, Sethi V, Saxena DB (1998) studies on identification of white specks in cured aonla (Emblica Officinalis Gacrtn,) fruits, Food Chem. 61 (12): 9-11.

Premwalli KS and Arya SS (1991) Effect of vegetables oils on the stability of carotenoids in Carrot-Halwa. Ind fd Packer 45 (4); 22-26

Purseglove JW (1968) Tropical Crops-Dicotyledons, The English Language Book society.

Ram SC (1983) Aonla (Emblica officinalis Gaetrn)uses-botany and culture, Directorate of Experiment station, G.B. Pant University of Agri. & Tech. Pantnagar.

Ramachandran BS, Ranganna S, Rao LSS and Kalbag SS (1996) An improved equipment for the manufacture of preserve. J. Food Sci. Technol., 3(3): 103.

Ramsey RJ and Milum VG (1933) The discolouration of honey. Amer Bee J 73:305.

Ranganna S (1994) Hand book of Analysis and quality control for fruit and vegetable products. Second Ed. Tata Mc. Graw-Hill Publishing Company Limited New Delhi.

Ranganna S (2002) Handbook of Analysis and quality Control for Fruit and Vegetable products.

Rani U and Bhatiya BS (1985) Studies on pear candy processing. Ind Fd Packer 39(5); 40-46.

Rao MRR and Siddiqui HH (1964) Indian J. Expt. Biol., 2: 29-31.

Ray PK and Majumdar SK (1976) Econ. Bot 30 : 317-320.

Redina EF, Mezhlumyan LG, Kasymova T D and Yuldashev PKH (1993) Chemistry of Natural Compounds, 29: 781-783.

Rosenblat G, Angonnet S, Grosohit A, Tabak M and Neeman I (1996) Anti oxidant properties of honey produced by bees fed with medical plant extracts. In: Bee Products; Properties, Application and Apitherapy (Mizrahi and Lensky, eds.), Plenum Press, New York, 49-55.

Ruck JA (1963) Chemical Methods for Analysis of fruits and vegetable Products, Canada Dept. of Agriculture, Publication No. 1154,9.

S K Saxena,Vikas Jaiswal (2005) Wonders of Golden Liquid Honey. Process Food Industry, August, 42-50.

Sastry LW, Satyanarayana MN, Srinivasan M, Subramanian N and Subrahmanyan V (1956) J. Sci Indus Res 15 : 70-80.

Schade J E, Marsh G L and Eckert J E (1958) Diastase activity and hydrogen methyl furfural in honey and their usefulness in detecting heat alteration, fd Res 23, 446.

Schmidt M (1978) Honey waffle. German Federal Republic Patent Application, 2701765.

Sethi V and Anand JC (1982) Studies on the preparation, quality and storage of Intermediate Moisture (IM) carrot preserve. J Fd Sci Technical 19 (July-Aug); 168-1 / /

Shamala TR and Jyothi YS (1999) Honey- It is more than just sweet, Indian Food Industr , Nov-Dec. 18(6): 349-357.

Sharma RC (2000) Honey; Processing and Product Development, Post harvest Technology of Fruits and vegetables, Indus Publishing Co., New Delhi.

Shoemaker J S (1947) Vegetable Growing, John, Wiley & Co. Sons. New York.

Siddappa GS 1982 Indian Food Ind 1: 73.

Singh IS and Pathak RK, Dwivedi R and Singh HK (1993) Aonla production and post harvest technology. Bull Deptt. of Hort., N.D. Univ. of Agric. and Technol. Faizabad, India.

Singh M (1988) Punjab Hort J 28: 50.

Singh M, Shivhare VS and Singh H and Bawa AS (1999) Osmotic Concentration Kinetics of amla preserve Ind. Fd. Packer, 53(1):13.

Singh Narpinder, Singh SJ, Bava AS and Sekhon KS (1988) Honey Its Food Uses. Indian Food Packer 42(6): 15.

Singh Pratibha, Singh JP and Chopra CS (2003) Techno-Economic study on Processing of Aonla Products, Beverage and Food World. January, 68-69.

Singh VK, George CK, Gupta KP and Gupta BN (1983) Sci. and Cult., 49: 354-356.

Siva Kumar, KP, D Melathi and B Nellakurmban (2007) Preparation and evaluation of guava toffee. Beverage and Food World 34(9): 68-70.

Srivastava PR and Kumar S (1994) Fruit and vegetable preservation principles and practices, International book Distributing Co. Ltd., Lucknow.

Srivastava RP and Srivastava RK (1964) Sci. and Cult., 30:446-447.

Tandon DK, Dikshit A, Kumar S and Shukla DK (2006) Evaluation of Aonla Varieties for preparation of segments in syrup. Beverage and Food World 33(12): 64-68.

Tariq M, Hussain SJ, Asif M and Mohan M (1977) Indian J. Expt. Biol., 15: 485-486.

Tripathi VK, Singh MB and Singh DS (1988) Chemical changes during storage of preserve and dehydrated products India Food Packer. 42(4): 60.

Tripathi VK, Singh MB and Singh Surjeet (1998) studies on comparative compositional changes in different preserved products of amla (Emblica Officinalis Gaertn.) var. Banarasi, Ind. Fd. Packer, 42(4):60.

Uusitupa MIJ(1994) Fructose in the diabetic diet. Am J Clin Nutr; 59(3 Suppl): S753-S57.4.

Veeranan V, Arun Giridhari and D. Malathi (2005) Nutritious and Tasty Mixed fruit bar, Processed Food Industry, 8(6):27-30.

Verma VS, Raychaudhary Sp and Khan AM (1969) Biol. Plant., Prague, 11: 384-387.

Vol. 2, Page No. 523.

Voll H (1974) New adaptation of honey to bread making. Bakers Dig., 48(4): 45, 48-49, 53.

Wakhle DM (1998) value addition to honey and bee products. FAO Workshop on sustainable bee keeping Development and all India honey festival (APIEXI-98) 1-5 August, Dharwed, Karnataka, India.

White JW and Subers MH (1963) Studies on honey inhibine. 2. A Chemical Assay J Apic Res 2: 93-100.

Wilson WC (1980) In: tropical and subtropical Fruits (Eds. S. Nagy and P.E. Shaw). Composition, Properties and Uses. AVI Publ. Inc., Westport, Connecticut.

Wootton M Edwards, R A Faraji-Haremi R and Jhonson AT (1976) Effect of accelerated storage conditions on the chemical composition and properties of Australian honeys. I. Colour acidity and total nitrogen content, J Apic Res 15, 23.

Yaniv Z and Rudich M (1996) Medicinal herbs as potential sources of high quality honeys. In: Bee Products; Properties, Application and Apitherapy (Mizrahi and Lensky, eds.), Plenum Press, New York, 77-81.